RELEASE NOTES

STAR-CD Version 3.2

CONFIDENTIAL — FOR AUTHORISED USERS ONLY

© 2005 CD-adapco

TABLE OF CONTENTS

Version 3.26 Release Notes

1 Introduction

2 Pre- and Post-processing Features

New Developments 2-1

Known Issues 2-3

3 STAR Features

New Developments 2-4

Other Developments 2-4

Known General Issues 2-5

Port-specific issues 2-6

Known HPC issues 2-7

Port-specific HPC issues 2-7

Batch-running issues 2-7

4 User Documentation

Version 3.24 Release Notes

1 Introduction

2 Pre- and Post-processing Features

New Developments 3-1

Known Issues 3-1

3 STAR Features

New Developments 3-2

Engine Combustion Modelling 3-2

Other Developments 3-3

Known General Issues 3-5

Port-specific issues 3-6

Known HPC issues 3-6

Port-specific HPC issues 3-7

Batch-running issues 3-7

4 User Documentation

Version 3.22 Release Notes

1 Introduction

2 Important Notes for Pre- and Post-processing

New Developments 4-1

Known Issues 4-1

Port-specific Issues 4-1

3 STAR Features

New Developments 4-2

Windows-specific Features 4-2

Known Issues 4-3

General issues 4-3

General HPC issues 4-4

Port-specific HPC issues 4-4

Other port-specific issues 4-4

4 User Documentation

Version 3.20 Release Notes

1 Introduction

2 Pre- and Post-Processing

pro-STAR Auto Mesh module ‘pro-am’ 1-1

CAD Import and Surface Meshing tool ‘pro-surf’ 1-1

STAR-Design 1-2

3 pro-STAR Features

General comments 1-2

Other Features 1-2

File Compatibility 1-3

4 Important Notes for pro-STAR

Changes of Practice 1-3

Known Issues 1-4

Liquid films 1-4

Transients 1-5

HiRes screen dump 1-5

StarWatch 1-5

Port-specific Issues 1-5

5 STAR Features

STAR-PNP (Plug & Play) 1-5

Dynamic Memory Allocation 1-6

STAR-Launch 1-6

Eulerian Two Phase 1-7
Turbulence Models 1-7
Wall Functions 1-7
Combustion Models 1-8
Material Properties 1-8
Lagrangian Two-phase Flow 1-8
Liquid Film Modelling 1-9
Free Surface and Cavitation 1-9
Engineering Data Output 1-9
Boundary Condition Enhancements 1-9
Anisotropic Conductivity in Solids 1-10
Tables for Sources and Initialisation 1-10
Radiation Features 1-10

6 STAR Beta-level Features

7 Code and File Structure Changes

8 Use of Switches and Constants

9 Important Notes for STAR

Changes of Practice 1-11
Stagnation boundary conditions 1-11
Lagrangian multi-phase cases 1-11
Numerical methods 1-12
STAR output 1-12
Free surface flows 1-12
The STAR Toolchest 1-13
Material properties 1-13
Radiation 1-13
Wall heat transfer 1-13
Known Issues 1-13
General issues 1-13
General HPC issues 1-15
Port-specific HPC issues 1-15
Other port-specific issues 1-15

10 User Coding

New User Subroutines 1-16
Removed User Subroutines 1-16
Modified User Subroutines 1-16
Guidelines for Upgrading User Subroutines to Version 3.2 1-17
User Defined Arrays 1-17
STAR Defined Arrays 1-18

11 User Documentation

Appendix A Summary of Command Changes

Appendix B Automatic Meshing — Version 3.20 Release Notes

New for release v3.20 ..... B-1
Previous Release Updates (in chronological order) B-1
v3102.515 Updates B-1
v3102.516 Updates B-2
v3102.517 Updates B-2
v3102.518 Updates B-2
v3103.519 Updates B-3
v3103.520 Updates B-4
v3103.521/522 Updates B-5

Appendix C CAD Import and Surface Meshing — Version 3.20 Release Notes

Important Points C-1
CAD File Import Notes C-2
Catia V4 ..... C-2
Catia V5 ..... C-2
Unigraphics C-2
Pro/ENGINEER C-2
TTF CAD Reader Licence Instructions C-3
Additional Windows 2000/XP Information C-3

Appendix D STAR-Design — Version 3.20 Release Notes

Introduction D-1
New Features in this Release D-1
Transitioning from Version 3.15 ..... D-1
Important Notes D-2
Frequently Asked Questions D-3

Version 3.26 Release Notes

1. Introduction

Version 3.26 is the latest update of the STAR-CD V3.2 suite, offering a number of additional features that are not available in the previous V3.20 — V3.24 releases. Note that this release has not been ported yet to the Windows platform.

2. Pre- and Post-processing Features

2.1 New Developments

The main areas of development were as follows:

1. A new surface wrapper tool was incorporated into pro-STAR's auto-meshing module (`prostar -amm`). Its main advantages over the previous tool are:
   (a) Much faster run times (by a factor of 4—10) and lower memory requirements (1/3—1/4 of the old tool)
   (b) Leak detection
   (c) Can close large surface gaps
   (d) Baffle inflation (assigns a finite thickness to internal shells representing baffles)
   (e) Variable refinement levels based on curvature and proximity
   (f) Localized surface properties to control mesh density
   (g) Edge retention
   (h) Contact prevention
2. The tetrahedral meshing option based on the TETGENERATE command has been formally removed from the auto-meshing GUI panels but is still available on the command line. The options for the Delaunay-based tetrahedral mesher were also enhanced in the same GUI panels.
3. Many improvements were made to pro-STAR's CAD import and surface preparation module (`prostar -surf`):
   (a) Additional native CAD file formats are now supported, due to integration of newer versions of the TTF library. These are:
      i) Catia V5 R11, R12, R13 and R14 files
      ii) Catia CATProduct files (i.e. assemblies)
      iii) Catia CGR files (up to V5 R13). This requires an additional TTF license.
      iv) Pro/ENGINEER WildFire 2 files
   (b) STL file import is supported
   (c) Improved performance of the NURBS evaluation, resulting in ~2 times speed-up of surface mesh generation
   (d) Improved performance of native CAD import (by eliminating unnecessary conversions of duplicate curves)
   (e) Fixes to many bugs concerning the surface mesh generation algorithm

(f) Descriptions of the various manual CAD repair tools were added to the User Guide
(g) A revised tutorial example has been included in the Tutorials volume

4. The batch-processing version of the surface module (`prosurf-batch`) also includes the following improvements:

   (a) Reads Catia CGR files
   (b) Reads STL files
   (c) Additional pro-surf controls are now available in batch mode (e.g. all mesh generation controls and the point and curve tolerances)
   (d) Writes mesh data as cell and vertex files

5. A free-standing view factor calculation module, FASTRAC, was added to the STAR-CD suite for use in surface-exchange radiation problems (see also Section 3.1 below). This calculation method is not currently supported for cases requiring

   (a) symmetry and cyclic boundaries
   (b) moving meshes
   (c) radiation sub-domains
   (d) a boundary patch analysis (data on the incident and transmitted radiative heat flux for a given patch as opposed to a given boundary region)

   Please also note that:

   (a) Patches generated by command `BPATCH` for use in the old radiation method cannot also be used for FASTRAC.
   (b) The FASTRAC patch specification method is different from that for the old method. Moreover, the patches are not generated until after the view factor calculation procedure has been initiated by command `VFCALC`.
   (c) When FASTRAC is used for solar radiation cases, only radiation incident on the active side of a patch is counted (the active side of the patch is towards the fluid cell, or away from the solid cell, that it is attached to). Thus, the external surfaces of opaque wall boundaries exposed to solar radiation will not experience any heating. If such heating is to be simulated, users must represent the wall boundary either by a thin layer of solid cells (and turn on conjugate heat transfer), or by a baffle plus an additional layer of fluid cells on its outward-facing side.
   (d) Some STAR runs using the FASTRAC method might fail with the message:

   *** ERROR: ABOVE PATCH WITH ZERO AREA BUT NON-ZERO VIEW FACTOR

   This happens because the FASTRAC radiation pre-processor sets the environmental patch area to zero, if the calculated area is less than an internal tolerance. This will typically occur in models where the cell sizes are small (eg. models built in meters). The error will be fixed in the next release.

   In the meantime, a possible workaround is to scale up the model with command VSCALE (vertices and coordinate systems) in pro-STAR before issuing the VFCA command. Note that an appropriate scaling factor should then be used with the GEOM command to "cancel out" the effect of this scaling up. At present, the environmental patch area is not available to the user, hence the determination of the scaling factor is a trial-and-error process.

2.2 Known Issues

1. Models containing baffles inside materials where radiation is not calculated (e.g. baffles in solids) produce erroneous radiation loads on the baffle. To avoid the problem, define boundaries on such baffles and set the transparency = 1.0 for these regions.
2. Linux ports:

   (a) Linux/Motif has problems with diamond shaped toggle buttons. If the user selects a diamond-shaped toggle button option in pro-STAR, does not save this setting, goes to another panel and then back to the original panel, the setting of the toggle button goes back to the previous saved value, and the user cannot select this toggle button option again.

   (b) There is an incompatibility between the extended mode (glm) driver in pro-STAR and certain NVIDIA drivers. Specifically, versions 1.0-5336 and 1.0-5328 of the NVIDIA drivers are known to cause the X server to crash upon exit from pro-STAR. This issue was partially resolved in V3.22 but may still occur in some rare instances and cannot be completely resolved without changing drivers. The NVIDIA 1.0-4436 drivers are known to be completely compatible with pro-STAR.

   (c) Linux64_2.4 Itanium systems — Due to restrictions imposed by the Parasolids kernel, STAR-Design is a 32 bit application and will not run on these systems unless 32 bit compatibility libraries are installed. On some systems where compatibility is provided, STAR-Design performance may be poor.

   (d) Linux64_2.4-x86 Opteron systems — Systems that are configured to support Unicode by default (the LANG environment variable is set to e.g. `en_US.UTF-8` or `en_GB.UTF-8`) will issue warning messages when running pro-STAR in OpenGL mode. A non-Unicode setting is required to stop the warning messages, for example by setting the LANG environment variable to `en_US` or `en_GB`).

3. Solaris port:
   The Sun pro-STAR port does not allow the user to cut and paste inside user defined panels and may cause the program to crash. Any task that brings up the file selection dialog will crash if the user logs in with any of the following setups:
   en-US
   en US.ISO08859 1
   en US.ISO08859 15
   It works for C POSIX and this is the environment recommended by SUN.

4. The STL file import feature in pro-STAR's CAD import and surface preparation module currently employs a strict interpretation of the format specification for coded (ASCII) STL files. It is therefore unable to read some STL files if their format deviates from the specification in the following ways:

   (a) Any keyword is written in upper case or mixed case characters
   (b) Any of the keywords "endloop", "endfacet" and "endsolid" includes a space (e.g., "end loop")
   (c) Any line begins with the keyword "color"

   Until this problem is fixed, you may work around it by editing the STL file so that it

conforms strictly to the file format specification.

3. STAR Features

3.1 New Developments

The main areas of development were as follows:

1. An improved method of modelling surface-exchange radiation problems (FASTRAC), based on a fast algorithm for calculating view factors with much smaller memory requirements. At present, this may be used only in non-participating media cases.
2. The participating media radiation capability was enhanced to include particle radiation effects (previously only available for coal combustion cases)
3. The following features were added to the ECFM engine combustion package:

   (a) A double-delay autoignition model
   (b) The AKTIM spark ignition model
   (c) An extention to the soot model, based on the method of moments, that also includes EGR effects

   Research is still in progress on items (b) and (c) above, so they should be treated as ***beta*** features. CD-adapco would also welcome feedback from users who have incorporated either of them in their models.
4. The coal blend model was enhanced to allow inclusion of non-coal particles within the flow, as in sulphur-in-coal or coal/biomass fuel blends.

Other Developments

1. The turbulent dispersion model for Lagrangian multi-phase simulations has been enhanced. Previously it was assumed that the eddy interaction time was much smaller than the computational time step in transient simulations; where this assumption was invalid the dispersion was inhibited. The eddy was also assumed not to persist when a particle passed through cyclic boundaries or was reflected from symmetry boundaries. These restrictive assumptions have now been removed, which will generally promote particle dispersion.
2. The practice of ensemble-averaging droplet source terms in steady-state Langrangian multi-phase simulations has been replaced by simple under-relaxation, using the standard "Under-Relaxation of Lagrangian Sources" parameter (default 0.35). The previous ensemble-averaging procedure can be recovered by setting Constant 24 to the iteration number at which averaging will begin.
3. The liquid film model was extended by including an unsteady term and the effects of gravity and wall acceleration in the momentum equation. In addition, the solution algorithm was improved to increase its accuracy and robustness and a threshold value introduced for the minimum liquid film mass in a wall cell. The latter is now set to 0.5E-15 (default). Users may change this value by adding the following lines in the pro-STAR Extended Data section:

   ```
   BEGIN LF_DATA
   LF_TRUNCATE
   new_threshold_value
   ```

END LF_DATA

4. An interface to HP MPI was added to all GNU/Linux ports of STAR-CD to enhance its parallel running capabilities. HP MPI supports Gigabit Ethernet, Myrinet and InfiniBand network interconnects. For further information, please consult:

   http://www.hp.com/go/mpi/

5. An interface to Intel MPI was added to the GNU/Linux port for Intel Itanium. Intel MPI supports Gigabit Ethernet, Myrinet and InfiniBand network interconnects. For further information, please consult:

   http://www.intel.com/software/products/cluster/mpi/

6. RA-MPICH has been integrated into the GNU/Linux port for the AMD Opteron processor. The RA-MPICH implementation of MPI is based on MPICH and requires Rapid Array network interconnects on the Cray XD1. For further information, please consult:

   http://www.cray.com/products/xd1/

7. The communication method used for moving mesh cases has changed. Previous STAR-CD versions used ‘fork’ by default but ‘socket’ could be selected instead. The current version uses ‘socket’ by default and ‘fork’ can be selected instead. This affects cases with a variable timestep which previously ran with fork communication but do not run "as is" with socket communication.
   To overcome this problem:

   (a) Use the `-fork` run option to force the old fork process
   (b) Use the `-nolookahead` option to disable look-ahead as this is not a valid option for fork communication

3.2 Known General Issues

1. The following issues concern radiative heat transfer:

   (a) For the Discrete Transfer method (DTRM), conducting walls (solid-fluid interfaces) should have their transmissivity set to either 1 or 0, depending on whether radiative heat transfer through the solid material is to be considered. If radiation in the solid is on, the transmissivity at the solid-fluid interface must be 1, otherwise it must be 0. Since the Discrete Ordinate method (DORM) does not support radiation in solids, the transmissivity at the solid-fluid interface must be set to 0.
   (b) The heat exchange between materials reported by STAR in the `.info` file represents only the heat exchange due to conduction.
   (c) Models with boundaries that have different thermal and solar transparencies, the post-processing quantity SRAD (solar radiosity) on the `.pst` file is incorrect. This does not affect the solution.
   (d) When models containing boundaries with reflectivity=1 and warped cells are run in double precision, a precision error in the code sometimes results in high temperatures at the reflective boundaries. To avoid the problem, set the reflectivity to 0.9999 or less.

(e) In models with boundaries that are fully transparent thermally but whose solar transparency is less than 1.0, the solar transparency is ignored, i.e. the boundary becomes fully transparent. Set the thermal transparency to 0.999 or less to avoid the problem.

2. The following issues concern liquid films:

   (a) Droplets impinging on a film are not converted to film if the 'Predictor Only' option is chosen for the solution procedure in panel *Lagrangian Multi-Phase* > *Droplet Controls*.
   (b) At present, momentum transfer will always be active for liquid films (i.e., the setting specified in pro-STAR has no effect).
   (c) In cases containing both sprays and liquid films, coupling between the liquid film and the gas phase follows the *Two-Phase Lagrangian Calculations* setting in panel *Lagrangian Multi-Phase* > *Droplet Controls*. If sprays are not present, the default setting is for coupled calculations. Note, however, that Switch 123 may be used to decouple them.
   (d) Liquid-film wall data do not appear in the `.run` file even when the user has specifically requested them

3. When using the Crank-Nicholson time discretisation scheme, the mass, energy and species fluxes appearing in the `.info` file are reported on the basis of the fully implicit scheme's differencing 'molecule', not the correct Crank-Nicholson 'molecule'.
4. The non-adiabatic implementation of the PPDF combustion model may not give accurate results as far as species mass fractions are concerned. This is due to the fact that species mass fractions are computed on the basis of adiabatic equilibrium conditions. The temperature, however, is re-computed based on the actual enthalpy.
5. Rotating reference frame cases using a Reynolds Stress turbulence model fail to converge.
6. The AMG solver requires that all mesh regions associated with a given material are connected.
7. The only differencing scheme employed by STAR when solving for density is CD. If the pro-STAR setting for density is MARS, STAR changes it internally to CD and uses a value of 0.7 for the blending factor. A message to this effect appears at the top of the `.run` file.
8. The Crevice sub-model of the ERC engine simulation package is not operational in this Release.

Port-specific issues

1. Solaris 5.7 port — STAR-Launch may hang on start-up if the user's home directory resides on a disk mounted on a Solaris 5.7 system.
2. Linux x86 port — Users of Red Hat 9.0 and Red Hat Enterprise Linux 3 (RHEL3) systems should note that there are bugs in Red Hat's x86 versions of the NPTL POSIX thread libraries. One confirmed effect of these bugs is for pro-STAR moving-mesh analyses to hang immediately after the geometry calculations. Another problem is that STAR V3.26, which uses FLEXlm 9.5 for licensing, may either crash with a segmentation fault or hang on unpatched systems.The required fix for RHEL3, RHBA-2004:384-11, can be downloaded from

`https://rhn.redhat.com/errata/RHBA-2004-384.html`

As Red Hat 9.0 is no longer supported by Red Hat, upgrading to RHEL3 is recommended. These problems have not been found to effect STAR on the Itanium and AMD64 versions of RHEL3; however Red Hat recommends that the patch mentioned above is applied to all RHEL3 systems.

3.3 Known HPC issues

1. Running STAR in parallel is not feasible for cases involving
   (a) The Discrete Transfer radiation model with participating media; for such cases users are advised to use the Discrete Ordinates radiation model
   (b) Solar radiation, unless the FASTRAC method is used to calculate view factors
2. Currently the AMG solver can run with a maximum of 256 processors.
3. In Lagrangian two-phase cases where the number of parcels is approximately equal to or greater than the number of cells, the following message may be reported on screen

   ```
   ...out of space on attached buffer...
   ```

   and the run subsequently stops. This is related to the MPI implementation being used. If you encounter this problem please contact CD adapco's User Support for information on how to overcome it.
4. Cases running MPICH 1.2.4 and the Shared Memory Communication device are unreliable and may fail. If this problem is encountered, a different MPI implementation should be used instead. Alternatively, the user may wish to use MPICH with shared memory communications disabled (e.g. `star -mpi=mpich -noshmem hostname,2`).
5. When using the FASTRAC view factor calculation method for models containing conjugate heat transfer interfaces or baffles, the latter must not lie at the interface between HPC subdomains (the `SETS` option in the `geomdecomp` program may be used to pick subdomains that satisfy this constraint).

Port-specific HPC issues

1. The Discrete Ordinates radiation model does not work correctly in parallel mode for the HP-UX and OSF1 platforms
2. The AIX port does not work with the MPICH 1.2.4 installation supplied with STAR-CD V3.20 and V3.22. Please install the MPICH 1.2.4 installation supplied with the STAR-CD V3.24 solver. If you compile your own MPICH installation, you may need to regenerate your `libmpi.so` dynamic shared object using:

   ```
   star -mkso $MPICH/ch_shmem/lib/shared/libmpi.so $MPICH/ch_shmem/lib/libmpi.a
   star -mkso $MPICH/ch_p4/lib/shared/libmpi.so $MPICH/ch_p4/lib/libmpi.a
   ```

3. The MPI implementation on HP-Alpha OSF1 clusters may fail. This applies to both HP-Alpha MC MPI (Memory Channel) and HP-Alpha SC MPI (elan) versions.

3.4 Batch-running issues

The STAR-CD 3.2x solvers support all resource managers that are also supported by

STAR-NET 3.x:

1. The latest STAR-NET 3.0.3 supports IBM Loadleveler, LSF, OpenPBS, PBSPro, Sun Grid Engine (SGE) and Torque.
2. The PBSPro and Torque resource managers are supported only in OpenPBS compatibility mode.

4. User Documentation

Further additions and corrections were introduced into the STAR-CD documentation set. As usual, the latest edition is accessible either from the pro-STAR Help menu (for manuals) or from STAR GUIde's Help button (for context-sensitive On-line Help topics). Users should note the following items:

1. Numerous changes were introduced throughout the documentation to cover the FASTRAC view factor calculation method. The chapters affected are:

   (a) Methodology Chapter 9
   (b) User Guide Chapter 7 (new surface radiation property definitions)
   (c) User Guide Chapter 11 (overview of how to set up radiation calculations)

   A number of on-line STAR GUIde Help topics and the User Guide and Methodology indices were also updated.
2. Chapters 5 and 9 of the Supplementary Notes volume were revised to incorporate the new coal blend and engine combustion simulation facilities, respectively.
3. A revised description of LES models was introduced in Chapter 2 of the Methodology volume.
4. The section on coal modelling in Chapter 12 of the User Guide was extensively re-written to include detailed information on setting up such models.
5. Tutorials 12.1 and 12.2 were modified to employ the new view factor calculation method described above.

Users are advised to check the on-line version of all documents (which now carry the new Version 3.26 number) for the latest updates to hard-copy manuals received under Version 3.20.

Version 3.24 Release Notes

1. Introduction

Version 3.24 is the latest update of the STAR-CD V3.2 suite, offering some bug fixes and a number of additional features that are not available in the previous V3.20 and V3.22 releases.

2. Pre- and Post-processing Features

2.1 New Developments

pro-STAR now includes an option for bringing up the IC (Internal Combustion) Setup tool. To access this facility, the user must start pro-STAR in auto-meshing mode (`prostar -amm`). The new panel can be displayed by selecting the **Automesh > IC Setup** option from the main window's menu bar.

2.2 Known Issues

1. Linux ports:

   (a) There is an incompatibility between the extended mode (glm) driver in pro-STAR and certain NVIDIA drivers. Specifically, versions 1.0-5336 and 1.0-5328 of the NVIDIA drivers are known to cause the X server to crash upon exit from pro-STAR. This issue was partially resolved in V3.22 but may still occur in some rare instances and cannot be completely resolved without changing drivers. The NVIDIA 1.0-4436 drivers are known to be completely compatible with pro-STAR.
   (b) Linux64_2.4 Itanium systems — Due to restrictions imposed by the Parasolids kernel, STAR-Design is a 32 bit application and will not run on these systems unless 32 bit compatibility libraries are installed. On some systems where compatibility is provided, STAR-Design performance may be poor.
   (c) Linux64_2.4-x86 Opteron systems — Systems that are configured to support Unicode by default (the LANG environment variable is set to e.g. `en_US.UTF-8` or `en_GB.UTF-8`) will issue warning messages when running pro-STAR in OpenGL mode. A non-Unicode setting is required to stop the warning messages, for example by setting the LANG environment variable to `en_US` or `en_GB`).

2. Microsoft Windows port:

   (a) pro-STAR user subroutines are not supported
   (b) The Mesa graphics option is not available for this platform
   (c) There is a compatibility problem between the supplied X server, SCO XVision, and certain integrated Intel graphics chipsets, resulting in 100% CPU usage by XVision.
   (d) Users with Windows XP Service Pack 2, or users who have a software firewall

installed, will encounter warnings regarding the blocking/unblocking of executable programs or network ports. You will need to keep the following unblocked:

i) The supplied X server. SCO XVision will trigger these warnings with "Vision Services" and "XVision 32-bit Server"
ii) pro-STAR components (`pro-x.exe`, `pro-xm.exe`, `pro-glm.exe`), `stardesign`, `prosurf`

(e) The CAD-enabled packages STAR-Works, STAR-Pro/E, and STAR-NX are not available in the STAR-CD V3.24 installation. Users requiring the CAD functionality need to continue using STAR-CD V3.150A until these packages become available in a future release.

3. STAR Features

3.1 New Developments

Engine Combustion Modelling

Two new engine combustion packages, ERC and ECFM, are now available to STAR-CD users under a special licence.

Prospective users of these packages who are upgrading from V3.15 should note that several modelling facilities have been ***extensively*** re-designed compared with V3.15. Such users should therefore check carefully that a previously created model is correctly and completely specified in the new V3.2 environment before attempting any STAR runs. Special attention should be paid to the following features:

1. ***Lagrangian multi-phase flow*** — After resuming from a Version 3.15 `mdl` file, the problem specification may not be complete and may need to be checked by the user. In particular:

   (a) If explicit parcel injection in transient mode is involved, the user will need to provide values for "Flow rate", "Start injection time" and "End injection time" using the new pro-STAR panels. However, the injection time may still be incorrectly written to the new injection table.
   (b) Injector flow rates specified in pro-STAR V3.2 are mass flow rates. Therefore, resuming from an old model file where volumetric flow rates are used involves an internal conversion which may not be correct and needs to be verified. The user also needs to specify the name of the table file in which the converted data are to be kept.
   (c) Users should take special note of the fact that pro-STAR V3.2 tables are dependent on whether time or crank angle is selected as the unit of time. Old-style tables, on the other hand, are defined in terms of time regardless of the time unit used.
   (d) The total injected fuel mass within the `.spd` file will be incorrect for cases with multiple fluid streams

2. ***Transient load steps —*** These remain available in pro-STAR V3.2 but will eventually be phased out in favour of transient tables. Users are advised to build any new transient analyses on the basis of tables. Transient output values and controls

that are new to pro-STAR V3.2 have not been generally made available for old-style load steps.

3. ***Transient output control*** — pro-STAR V3.2 uses time units to specify the frequency of data output to `.pstt` files whereas earlier versions use number of time steps. Thus, when resuming from an old model file, the new-style output frequency cannot be calculated if the time step size is not known.
4. ***Command scripts*** — The end-result of V3.2 command scripts may differ from that of the equivalent V3.15 commands, even after all changes in parameters outlined in Appendix A have been implemented. Users should therefore check their models carefully to see if any corrective action is needed.

Users upgrading other engine combustion cases from V3.15 should also be aware that there are important differences in the V3.2 implementation of Shell and 4-Step ignition models relative to V3.15:

- The default method of calculating specific heats for species is to use the specific heat polynomial coefficients defined in pro-STAR. To use the hard-coded polynomial coefficients previously employed in V3.15 for these models, users have to turn on Switch 164.
- Option **Use Heat of Reaction** in the *Reaction System* STAR GUIde panel is valid only when the pro-STAR-defined specific heat polynomial coefficients are used. When the hard-coded polynomial coefficients are employed, Constant 96 becomes valid and may be used to specify the heat of reaction.

Other Developments

1. A new procedure for coupling STAR-CD to Gamma Technologies' GT-SUITE (GT-POWER, GT-COOL, GT-FUEL) has been implemented through STAR-PNP. The interface requires STAR-CD V3.24 or later and GT-SUITE V6.1 or later. Further information is given in Chapter 10 of the Supplementary Notes. Note that:

   (a) Three platforms (HP-UX, Linux Itanium and SunOS) require patches to GT-SUITE V6.1 before they can be used for STAR/GT-SUITE coupling.
   (b) The Windows port has only been validated against V6.1
   (c) The Windows environment variable GTIHOME will need to be checked. All path backslashes (\) need to be escaped with a backslash (e.g. `C:\gti` will not work, it must be `C:\\gti`).
2. A new procedure for coupling STAR-CD to Ricardo's WAVE code has been implemented as a plugin to STAR. This is available as part of the default STAR-CD installation, together with a User Guide that is accessed through the pro-STAR Help menu. All standard UNIX and Linux ports of STAR-CD are supported, although extra RSimlink libraries may be required (see the User Guide for more information). The only known limitations are on SunOS platforms: SUN MPI may not be used for parallel runs, and WAVE cannot currently be run as a child of STAR, pending a patch from Ricardo.
3. Switches 14 and 68 have been removed as obsolete. The same functionality is possible with the *User-f(T,p)* option for density: specify the required (constant) density in the `DENSIT` subroutine and set parameter `DENDP` to 2.0*`SMALL`.
4. The Anisotropic Conduction in Solids feature now allows user coding to supply principal conductivity coefficients. The set-up procedure is as follows:

(a) Select the Anisotropic Conductivity option for solids via the pro-STAR GUI
(b) Use the EDATA command or the Extended Data GUI panel to add keyword `ANISO_UCODE` to the problem file
(c) Write the `conduc.f` user subroutine to the `ufile` sub-directory and then edit it accordingly

5. The following developments have been implemented for free-surface modelling:

   (a) The surface tension model has been improved, by applying a smoothing function to the volume fraction (VOF) field when calculating the curvature of the gas-liquid or liquid-liquid interface.
   (b) Apart from the default Crank-Nicholson temporal differencing scheme, an Euler-implicit scheme is now offered for the solution of the volume fraction transport equation. This is activated by Switch 158.
   (c) The buoyancy effect on turbulence energy generation is taken into account when the buoyancy force is activated. For some cases where both buoyancy and turbulence effects are large, a smaller time step may be needed for numerical stability.

6. A default set of STAR-PNP run options may be defined for general use, and these may be tailored to site-specific conditions. Please refer to Appendix H of the User Guide for further information.
7. Users can avoid using the insecure `rsh`, `remsh` and `rcp` tools when starting remote tasks or remote copying of files. Any one of the alternative secure tools such as Kerberos or Secure Shell (`ssh`) may be used instead. This option is defined by `REMOTETASK` and `REMOTECOPY` settings in the `hardware.ini` file as in the following examples:

   ```
   REMOTETASK=ssh
   REMOTECOPY=scp

   REMOTETASK=/usr/kerberos/bin/rsh
   REMOTECOPY=/usr/kerberos/bin/rcp
   ```

   This facility works by using a wrapper script to redirect `rsh`, `remsh` and `rcp` calls to the alternative remote commands specified. If you wish to select a more secure protocol as the method of authenticating remote connections, you need to configure your environment so that no password or secret passphrase is needed to login to the remote nodes for parallel programs to work properly.

   You are recommended to use the new MPICH 1.2.4 installations supplied with the STAR V3.24 solver. Otherwise, you ***must*** compile MPICH using the `-rsh=rsh` configuration option (`-rsh=remsh` on HP-UX) to remove the hardwired remote command. This is so that a single MPICH installation can support Kerberos, Secure Shell or any other remote tool as well as the standard remote shell.
8. It is now possible to compile user subroutines that require additional dynamic shared objects. User subroutines can also be supplied as pre-compiled static libraries.
9. It is also possible to run the STAR solver using distributed data without mounting a NFS disk onto the remote nodes in order to start a parallel run. When running the STAR solver on clusters without NFS the following limitations apply:

(a) A local installation of STAR-CD and its associated software (such as LAM MPI, MPICH and RUNTIME) ***must*** be installed in the same path on all nodes (i.e. `/opt/starcd`)
(b) The STAR solver master process ***must*** be able to access the disk where the case files can be found. This means that if you are logged on `hostA`, this host name ***must*** occur first in the resource allocation (i.e. `star hostA hostB hostC`).
(c) If the master node crashes, the STAR processes running on the slave processors will not terminate properly.
(d) Remote compilation of user coding (i.e. `COMPILERHOST`) is not supported.
(e) Remote geometry decomposition (i.e. `-decomphost=hostlist`) is not supported.
(f) Remote merging of data (i.e. `-mergehost=hostlist`) is not supported.
(g) A job running under a batch system will not find its files and will fail.

3.2 Known General Issues

1. There are three known issues concerning thermal radiation:

   (a) The transmissivity for ‘external’ walls must be set to 0. In this instance, external walls are defined as all walls except conducting walls adjacent to solid-fluid interfaces.
   (b) For the Discrete Transfer method (DTRM), conducting walls (solid-fluid interfaces) should have their transmissivity set to either 1 or 0, depending on whether radiative heat transfer through the solid material is to be considered. If radiation in the solid is on, the transmissivity at the solid-fluid interface must be 1, otherwise it must be 0.
   (c) The heat exchange between materials reported by STAR in the `.info` file represents only the heat exchange due to conduction.

2. The following issues concern liquid films:

   (a) Droplets impinging on a film are not converted to film if the Lagrangian two-phase solution procedure is set to Predictor Only.
   (b) At present, momentum transfer will always be active for liquid films (i.e., the setting specified in pro-STAR has no effect).
   (c) Coupling between liquid film and gas phase follows the Lagrangian two-phase setting. Switch 123 can be used to decouple the liquid film from the gas phase when the Lagrangian two-phase option is inactive.
   (d) Liquid-film wall data do not appear in the `.run` file even when the user has specifically requested them

3. When using the Crank-Nicholson time discretisation scheme, the mass, energy and species fluxes appearing in the `.info` file are reported on the basis of the fully implicit scheme’s differencing ‘molecule’, not the correct Crank-Nicholson ‘molecule’.
4. The non-adiabatic implementation of the PPDF combustion model may not give accurate results as far as species mass fractions are concerned. This is due to the fact that species mass fractions are computed on the basis of adiabatic equilibrium conditions. The temperature, however, is re-computed based on the actual enthalpy.
5. Rotating reference frame cases using a Reynolds Stress turbulence model fail to

converge.

6. The AMG solver requires that all mesh regions associated with a given material are connected.
7. The only differencing scheme employed by STAR when solving for density is CD. If the pro-STAR setting for density is MARS, STAR changes it internally to CD and uses a value of 0.7 for the blending factor.
8. The Crevice sub-model of the ERC engine simulation package is not operational in this Release.

Port-specific issues

1. Solaris 5.7 port — STAR-Launch may hang on start-up if the user's home directory resides on a disk mounted on a Solaris 5.7 system.
2. Linux x86 port — Users of Red Hat 9.0 and Red Hat Enterprise Linux 3 (RHEL3) systems should note that there are bugs in Red Hat's x86 versions of the NPTL POSIX thread libraries. One confirmed effect of these bugs is for pro-STAR moving-mesh analyses to hang immediately after the geometry calculations. Another serious problem is that STAR V3.24, which now uses FLEXlm 9.5 for licensing, may either crash with a segmentation fault or hang on unpatched systems.The required fix for RHEL3, RHBA-2004:384-11, can be downloaded from

   `https://rhn.redhat.com/errata/RHBA-2004-384.html`

   As Red Hat 9.0 is no longer supported by Red Hat, upgrading to RHEL3 is recommended. These problems have not been found to effect STAR on the Itanium and AMD64 versions of RHEL3; however Red Hat recommends that the patch mentioned above is applied to all RHEL3 systems.
3. Windows port:

   (a) The default STAR-CD mode of operation is to use memory-based scratch files. On the Microsoft Windows platform, however, this may cause STAR to crash under certain circumstances. Use the `-noramfiles` option as a workaround.

   (b) Users with Windows XP Service Pack 2, or users who have a software firewall installed will encounter warnings regarding the blocking/unblocking of executable programs or network ports. You will need to keep the following unblocked:

      i) `star`
      ii) `mpich`-related components (`mpirun`, `mpd` daemon)
      iii) `starwatch` and `starwatch` daemon

3.3 Known HPC issues

1. Running STAR in parallel is not feasible for cases involving

   (a) The Discrete Beams radiation model with participating media; for such cases users are advised to use the Discrete Ordinates radiation model

   (b) Solar radiation

2. Currently the AMG solver can run with a maximum of 256 processors.
3. In Lagrangian two-phase cases where the number of parcels is approximately equal

to or greater than the number of cells, the following message may be reported on screen

```
...out of space on attached buffer...
```

and the run subsequently stops. This is related to the MPI implementation being used. If you encounter this problem please contact CD adapco's User Support for information on how to overcome it.

4. Cases running MPICH 1.2.4 and the Shared Memory Communication device are unreliable and may fail. If this problem is encountered, a different MPI implementation should be used instead. Alternatively, the user may wish to use MPICH with shared memory communications disabled (e.g. `star -mpi=mpich -noshmem hostname,2`).

Port-specific HPC issues

1. The Discrete Ordinates radiation model does not work correctly in parallel mode for the HP-UX and OSF1 platforms
2. The AIX port does not work with the old MPICH 1.2.4 installation supplied with STAR-CD V3.20 and V3.22. Please install the new MPICH 1.2.4 installation supplied with the STAR-CD V3.24 solver. If you compile your own MPICH installation, you may need to regenerate your `libmpi.so` dynamic shared object using:

```
star -mkso $MPICH/ch_shmem/lib/shared/libmpi.so $MPICH/ch_shmem/lib/libmpi.a
star -mkso $MPICH/ch_p4/lib/shared/libmpi.so $MPICH/ch_p4/lib/libmpi.a
```

3. The MPI implementation on HP-Alpha OSF1 clusters may fail. This applies to both HP-Alpha MC MPI (Memory Channel) and HP-Alpha SC MPI (elan) versions.
4. Extensive testing of the solver for distributed memory problems is still in progress for the Windows platform. Users who are interested in running with this configuration are therefore advised to contact CD adapco's User Support. The following points should be noted in particular:

   (a) Distributed memory STAR jobs need to be run over a dedicated network.
   (b) Distributed memory moving-mesh STAR jobs are not currently supported. Note, however, that shared memory moving-mesh jobs are supported.
   (c) Users wanting to run distributed memory clusters comprising more than eight machines will need to install a server version of Windows.

3.4 Batch-running issues

The STAR-CD 3.2x solvers support all resource managers that are also supported by STAR-NET 3.x:

1. The latest STAR-NET 3.0.3 supports IBM Loadleveler, LSF, OpenPBS, PBSPro, Sun Grid Engine (SGE) and Torque.
2. The PBSPro and Torque resource managers are supported only in OpenPBS compatibility mode.
3. STAR-NET and queuing systems are not currently supported on the Windows platform.

4. User Documentation

Further additions and corrections were introduced into the STAR-CD documentation set. As usual, the latest edition is accessible either from the pro-STAR Help menu (for manuals) or from STAR GUIde's Help button (for context-sensitive On-line Help topics). Users should note the following items:

1. Two new chapters, describing the additional engine combustion simulation packages now available under STAR-CD, were added to the Supplementary Notes. Chapter 8 covers the ERC package, Chapter 9 the ECFM package.
2. A detailed description of how to use STAR-CD in conjunction with one of the GT-SUITE packages is now included in the Supplementary Notes, Chapter 10.
3. Additional Useful Points applicable to complex chemistry and ignition models were added to Chapter 12 of the User Guide.
4. The LES turbulence model description in Chapter 2 of the Methodology volume has been extensively revised.
5. Appendix H of the User Guide contains an updated description of STAR batch runs under the queuing systems currently supported by the latest STAR-NET 3.0.3 (IBM Loadleveler, LSF, OpenPBS, PBSPro, SGE and Torque).
6. Four new tutorials were added to the Tutorials volume:
   (a) Tutorial 16.3 is an Eulerian two-phase simulation of a fluidised bed, of the type used in fluidised catalytic crackers
   (b) Tutorial 16.4 is an Eulerian two-phase simulation of boiling in a channel flow
   (c) Tutorial 17.1 is a 2D simulation of a liquid film drop flowing down a vertical wall
   (d) Tutorial 17.2 is a 3D simulation of liquid film formation and transport due to spray impingement on a wall
7. The Index in both the User Guide and Methodology volumes has been updated to better reflect the new V3.2 features

Users are advised to check the on-line version of all documents (which now carry the new Version 3.24 number) for the latest updates to hard-copy manuals received under Version 3.20.

Version 3.22 Release Notes

1. Introduction

Version 3.22 is an update of the STAR-CD Version 3.20 suite, offering several bug fixes and additional features that were not available in time for the initial 3.20 release. Version 3.22 also represents the initial release of STAR-CD 3.2X on the Microsoft Windows platform. All notes relating to new features and specifications for Version 3.20 are also applicable to the Windows version, apart from the exceptions specifically mentioned below.

2. Important Notes for Pre- and Post-processing

There are very few changes for pre- and post-processing. A number of bugs have been fixed, but very little else has changed.

2.1 New Developments

1. The visualization tool from the STAR-Design package can be used in stand-alone mode to post-process results from any STAR analysis. It can be started from the STAR-Launch interface (select `Pre-Post > STAR-Design/post` in the menu bar) or from the command line (type `stardesign -post`).
2. The program formerly known as ‘pro-surf’ is now the CAD import and surface preparation module of pro-STAR. It can be started from the STAR-Launch interface (select `Pre-Post > pro-STAR/surf` in the menu bar) or from the command line (type `prostar -surf`). The surface module also has a new batch mode of operation which can be started from the command line by typing `prostar -surf batch`. More information about batch mode and how to use it appears in Chapter 5 of the "User Guide: CAD Import and Surface Meshing Tool" document.
3. The program formerly known as ‘pro-am’ is now the automated meshing module of pro-STAR. It can be started from the STAR-Launch interface (select `Pre-Post > pro-STAR/amm`) or from the command line (type `prostar -amm`).

2.2 Known Issues

Port-specific Issues

1. Linux ports — There is an incompatibility between the extended mode (glm) driver in pro-STAR and certain NVIDIA drivers. Specifically, versions 1.0-5336 and 1.0-5328 of the NVIDIA drivers are known to cause the X server to crash upon exit from pro-STAR. This issue has been partially resolved in this release, but may still occur in some rare instances and cannot be completely resolved without changing drivers. The NVIDIA 1.0-4436 drivers are known to be completely compatibile with pro-STAR.

2. Microsoft Windows port:

   (a) pro-STAR user subroutines are not supported
   (b) The Mesa graphics option is not available for this platform
   (c) There is a compatibility problem between the supplied X server, SCO XVision, and certain integrated Intel graphics chipsets, resulting in 100% CPU usage by XVision.
   (d) Users with Windows XP Service Pack 2, or users who have a software firewall installed, will encounter warnings regarding the blocking/unblocking of executable programs or network ports. You will need to keep the following unblocked:

      i) The supplied X server. SCO XVision will trigger these warnings with "Vision Services" and "XVision 32-bit Server"
      ii) pro-STAR components (`pro-x.exe`, `pro-xm.exe`, `pro-glm.exe`), `stardesign`, `prosurf`

   (e) The CAD Plugin packages STAR-Works, STAR-Pro/E, and STAR-NX are not available in the STAR-CD V3.22 installation. Users requiring the CAD Plugin functionality need to continue using STAR-CD V3.150A until these packages become available in a future release.

3. STAR Features

3.1 New Developments

1. Chemical reaction modelling by means of the STAR/KINetics package is now available under a special license. A separate STAR/KINetics Manual will be supplied to users of this package.
   Note: The STAR/KINetics package is not currently available on the Microsoft Windows platform. Windows support for the package has been deferred to a future STAR-CD release.
2. STAR-CD's free surface and cavitation modelling capabilities have been extended to quasi steady-state cases by means of the pseudo-transient solution method; relevant details are given in the new V3.22 edition of the User Guide. When using this facility via the STAR GUIde interface, please note that:

   (a) The case has to be defined as 'Free Surface' or 'Cavitation' ***before*** selecting the 'Pseudo-Transient' solution option, not the other way round
   (b) Only the default solution algorithm, SIMPLE, should be employed for the CFD analysis

3.2 Windows-specific Features

1. When running STAR-PNP on the Microsoft Windows port, NFS is not used. Instead, users must have permission to create/mount/delete network-shared directories. Users on the Windows XP platform must disable the simple file sharing option. Mixed Windows 2000 and Windows XP clusters will need to have their security policies adjusted to match each other (force guest should be removed).
2. STAR-Launch replaces the earlier Windows `starlauncher` application to provide a consistent user interface between UNIX and Windows. On the latter

platform, STAR-Launch is activated by clicking the STAR-CD icon on the user's desktop.
3. The MPI timing option is not currently supported.
4. The STAR-Launch tool includes an option to open a MSYS shell which provides users with a UNIX-like Bash shell in the `Help` > `STAR Shell` menu.

3.3 Known Issues

General issues

1. The GT-POWER interface has been deferred to the next STAR-CD release
2. There are two known issues concerning thermal radiation:

   (a) The transmissivity for external walls must be set to 0. External walls are all walls except conducting walls adjacent to solid-fluid interfaces.
   (b) At conducting walls (solid-fluid interfaces), the transmissivity at the solid-fluid interface must be either 1 or 0, depending on whether radiative heat transfer through the solid material is to be considered. If radiation in the solid is on, the transmissivity at the solid-fluid interface must be 1, otherwise it must be 0.

3. The following issues concern liquid films:

   (a) Droplets impinging on a film are not converted to film if the Lagrangian two-phase solution procedure is set to Predictor Only.
   (b) At present, momentum transfer will always be active for liquid films (i.e., the setting specified in pro-STAR has no effect).
   (c) Coupling between liquid film and gas phase follows the Lagrangian two-phase setting. Switch 123 can be used to decouple the liquid film from the gas phase when the Lagrangian two-phase option is inactive.
   (d) Liquid-film wall data do not appear in the `.run` file even when the user has specifically requested them

4. When using the Crank-Nicholson time discretisation scheme, the mass, energy and species fluxes appearing in the `.info` file are reported on the basis of the fully implicit scheme's differencing 'molecule', not the correct Crank-Nicholson 'molecule'.
5. The non-adiabatic implementation of the PPDF combustion model may not give accurate results as far as species mass fractions are concerned. Work is in progress to rectify this by modifying the code to compute both species mass fractions and temperature from the enthalpy obtained from the transport equation solution. The modification will also allow treatment of multiple air or fuel inlets with the same composition but different temperatures using a single mixture fraction. For streams of different composition, however, the multi-fuel PPDF option should be used instead.
6. Rotating reference frame cases using a Reynolds Stress turbulence model fail to converge.
7. When the k-ω SST model is applied to cases involving heat transfer in impinging flow regions, the calculated heat transfer coefficients do not agree with experimental results at present.
8. The AMG solver requires that all mesh regions associated with a given material are connected.

General HPC issues

1. STAR-HPC runs are not feasible for cases involving

   (a) The Discrete Beams radiation model with participating media; for such cases users are advised to use the Discrete Ordinates radiation model
   (b) Solar radiation

2. Currently the AMG solver can run with a maximum of 256 processors.
3. In Lagrangian two-phase cases where the number of parcels is approximately equal to or greater than the number of cells, the following message may appear on screen

   ```
   ...out of space on attached buffer...
   ```

   and the run subsequently stops. This is related to the MPI implementation being used. If you encounter this problem please contact CD adapco's User Support for information on how to overcome it.
4. Cases running with MPICH V1.2.4 and the Shared Memory Communication device are unreliable and may fail. If this problem is encountered, a different MPI implementation should be used instead. Alternatively, users may wish to use MPICH with shared memory communications disabled (e.g. `star -mpi=mpich -noshmem hostname,2`).

Port-specific HPC issues

1. Lagrangian multi-phase cases running on IRIX MIPS platform using the SGI MIPS MPI may lose droplets as they pass between sub-domains. If this problem is encountered, MPICH should be used instead.
2. Linux runs using the default geometry decomposition method (Metis) decompose the model in a different way to that of other platforms. This may produce results and convergence behaviour that are different to those for other platforms.
3. The Discrete Ordinates radiation model does not work correctly in HPC mode for the OSF1 and HP-UX platforms.
4. STAR-CD currently does not support any queuing systems on the Microsoft Windows platform as there is no STAR-NET port for Windows.
5. Extensive testing of the solver for distributed memory problems is still in progress for the Windows platform. Users who are interested in running with this configuration are therefore advised to contact CD adapco's User Support. The following points should be noted in particular:

   (a) Distributed memory STAR jobs need to be run over a dedicated network.
   (b) Distributed memory moving mesh STAR jobs are not currently supported. Note, however, that shared memory moving mesh jobs are supported.
   (c) Users wanting to run distributed memory clusters comprising more than eight machines will need to install a server version of Windows.

Other port-specific issues

1. IRIX port — Users of IRIX systems prior to 6.5.19f should note that problems may be encountered compiling user subroutines if these subroutines reside on a file system NFS-mounted from Solaris systems or from certain Linux systems (all Reiserfs filesystems and ext3 on SuSE 8.2). A workaround will be introduced in the STAR-CD 3.24 solver.

2. Solaris port — STAR-Launch may hang on start-up if the user's home directory resides on a disk mounted on a Solaris 5.7 system.
3. Windows port:

   (a) The default STAR-CD mode of operation is to use memory-based scratch files. On the Microsoft Windows platform, however, this may cause STAR to crash under certain circumstances. Use the `-noramfiles` option as a workaround.
   (b) pro-STAR may fail to generate an SMAP file on some Windows machines. You may use the SMAP file generated by another platform as a workaround.
   (c) Users with Windows XP Service Pack 2, or users who have a software firewall installed will encounter warnings regarding the blocking/unblocking of executable programs or network ports. You will need to keep the following unblocked:

      i) `star`
      ii) `mpich`-related components (`mpirun`, `mpd` daemon)
      iii) `starwatch` and `starwatch` daemon

4. User Documentation

A number of additions and corrections were introduced into the STAR-CD documentation set since hard copy manuals for Version 3.20 were printed in March 2004. As usual, this new edition is accessible either from the pro-STAR Help menu (for manuals) or from STAR GUIde's Help button (for context-sensitive On-line Help topics). Users should especially note the following items:

- Details of the MPI nozzle flow, atomisation and droplet-wall interaction models are given in Chapter 12 of the Methodology volume
- The 'four-step' Diesel ignition model is described in Chapter 11 of the Methodology volume
- Appendix H of the User Guide contains a description of STAR batch runs under the currently supported queuing systems (LSF, OpenPBS and Sun Grid Engine)
- The free surface and cavitation model theory and usage instructions (Methodology Chapter 14 and User Guide Chapter 15, respectively) have been revised
- The Index in both the User Guide and Methodology volumes has been updated to include references to new V3.20 features

Users are advised to check the on-line version of all documents (which now carry the new Version 3.22 number) for the latest updates to hard-copy manuals received under Version 3.20.

Version 3.20 Release Notes

1. Introduction

Version 3.20 is a major new release of the STAR-CD suite, offering greatly enhanced capabilities in both the pre- and post-processing areas and in the scope of CFD problems that can be modelled. The release covers Unix and Linux ports; the Microsoft Windows port is deferred to Version 3.22.

2. Pre- and Post-Processing

The standard STAR-CD v3.20 bundle includes three tools in addition to pro-STAR for use in setting up simulation cases. These are introduced in the next three sections before presenting the new features of pro-STAR v3.20.

2.1 pro-STAR Auto Mesh module ‘pro-am’

The pro-STAR Auto Mesh module, or pro-am for short, provides the user with a powerful meshing environment capable of handling complex grid-generation tasks for the CFD solvers supplied by the CD adapco Group, namely STAR-CD, Comet and STAR-CCM+. It features capabilities such as new surface creation, surface repair and subsurface generation, plus a wide range of other tools and operations related to high-quality mesh generation. pro-am is capable of automatically creating up to three different types of mesh:

Trimmed:	Hexahedral-based mesh with trimmed type polyhedral cells
Tetrahedral:	Tetrahedral cells
Hybrid:	Hexahedral core with pyramidal and tetrahedral cells

pro-STAR can be started with or without the pro-am capabilities. To access these capabilities, type

```
proam
```

or click the appropriate button on the STAR-Launch interface (see section “STAR-Launch” on page 6 below). Detailed Release Notes for pro-am may be found in Appendix B of this document.

2.2 CAD Import and Surface Meshing tool ‘pro-surf’

pro-surf is a stand-alone package designed to read CAD data from a file written in one of several supported formats, repair many common CAD problems either automatically or manually, and triangulate the surface in preparation for use by pro-am or other volume meshing programs. This tool simplifies the process of converting CAD surface and curve data into a surface mesh that captures all features and resolves all geometric shapes. Its methodology automates many of the tedious CAD repair operations, reducing the time and effort required by a user to obtain a complete and closed surface geometry with no

holes or gaps.

To start pro-surf, click the appropriate button on the STAR-Launch interface or type `prosurf`. Detailed Release Notes for pro-surf may be found in Appendix C of this document.

2.3 STAR-Design

STAR-Design is one of the new generation of fully integrated CAD-CFD tools being developed by the CD adapco Group. The program's core is based on a solid modelling engine that is integrated with all necessary tools for performing a CFD analysis. This allows design engineers to create and assemble models of interest, set up any necessary flow conditions, generate a mesh, run and view the results; all within a single graphical interface. Since the solid modeller tracks the parametric values used during mesh construction, design modifications can be applied quickly and the flow analysis re-run with very little effort.

To start STAR-Design, click on the appropriate location on the STAR-Launch interface or type `stardesign`. Detailed Release Notes for STAR-Design may be found in Appendix D of this document.

3. pro-STAR Features

3.1 General comments

Considerable effort has gone into upgrading pro-STAR's STAR-GUIde interface in order to support the new STAR v3.20 modelling capabilities, as listed in section "STAR Features" on page 5 of these Release Notes. Some panels for existing features have also been redesigned to improve the way in which cases are set up.

Other Features

Many of the "new" features available in pro-STAR 3.20 have been released in patches since the original v3.15A release. These include, but are not limited to, items in the following list:

- ***Major upgrade to OpenGL graphics capabilities*** — It is now possible to plot almost everything available in the older "X-motif" window in a new "GL-motif" window. For users who do not have GL-enabled hardware, another mode named `mesa` is available in which all OpenGL features (translucency, lighting of post-processing plots, etc.) can be simulated in software. Mesa graphics are not usually very fast, but they do allow a wider range of graphics capabilities to users without special hardware.
- ***Options exist to save bitmap graphics (i.e. OpenGL hardware generated images) in a variety of formats and resolutions*** — These pictures can be produced in batch where no graphics cards are available using mesa graphics.
- ***A new lightweight 3-D viewer*** — This viewer runs on all platforms without requiring a license and allows you to rotate and zoom previously stored images. The viewer can be started by typing `starview`. Images can be prepared in pro-STAR using the SCENE command or by employing the *Write STAR-CD Scene File* option available under the *Utility* menu.
- ***Particle tracking has been extensively re-written*** — Additional options are available for describing particle starting points and for restricting particles to within

a small distance of a surface (to simulate oil streaks). Particle tracking within OpenGL can be especially effective when translucency and lighting is applied to exterior surfaces.

- ***Boundary specification facilities have been rationalised*** — All options present in the Boundary Tool of v3.15 have been moved into STAR GUIde, mostly under panel *Create Boundaries*. As a result, the Boundary Tool has been removed from the interface.
- ***The scope of tables as a medium for data input has increased*** — There is a very considerable increase in the number of facilities for defining, plotting, importing and exporting tabular data.
- ***The STARWATCH utility*** — The existing option for watching residuals in real time has been extensively rewritten and the utility now allows users to modify a number of parameters (residual tolerances, under-relaxation parameters, etc.) on the fly. The analysis then uses the updated parameters at the beginning of the next iteration. A history of parameter changes can be kept and used to rerun an analysis with the same changes taking place at the same iteration.

File Compatibility

- Model (`.mdl`) files from older pro-STAR versions (v3.15 and below) should be readable in v3.20. However, in cases where the data now required have changed significantly, particularly in the Free Surface and Chemistry areas, the data may not always make perfect sense in the new setting. Users should therefore look through the information retrieved from older pro-STAR versions very carefully (see section "Changes of Practice" below). An effort has also been made to read pro-STAR Switches and Constants from older files and translate them into v3.20 features where possible. Users should therefore be very careful when using such facilities as the same Switches and Constants in v3.20 may have a different meaning compared to v3.15.
- The `.geom`, `.prob`, and `parm.inc` files written by pro-STAR have all changed. Users must write all STAR v3.20 solver files from pro-STAR 3.20 and not reuse old ones.
- The `.pst` and `.pstt` files of v3.20 are completely new and different from older files. pro-STAR and STAR can read older files, but will write all files in the new format.

4. Important Notes for pro-STAR

4.1 Changes of Practice

Several modelling facilities have been ***extensively*** re-designed as compared with v3.15. Users should therefore check carefully that a previously created model is correctly and completely specified in the new v3.2 environment before attempting any STAR runs. Special attention should therefore be paid to cases containing the following features:

1. ***Lagrangian multi-phase flow*** — After resuming from a Version 3.15 `.mdl` file, the problem specification may not be complete and may need to be checked by the user. In particular:

   (a) If explicit parcel injection in transient mode is involved, the user will need to provide values for "Flow rate", "Start injection time" and "End injection time"

using the new pro-STAR panels. However, the injection time may be incorrectly written to the new injection table.

(b) Injector flow rates specified in pro-STAR v3.20 are mass flow rates. Therefore, resuming from an old model file where volumetric flow rates are used involves an internal conversion which may not be correct and needs to be verified. The user also needs to specify the name of the table file in which the converted data are to be kept.

(c) Users should take special note of the fact that pro-STAR v3.20 tables are dependent on whether time or crank angle is selected as the unit of time. Old-style tables, on the other hand, are defined in terms of time regardless of the time unit used.

(d) The total injected fuel mass within the `.spd` file will be incorrect for cases with multiple fluid streams

2. ***Buoyancy*** — The specification of body forces (gravity) is now universal and may be applied to any material. Buoyancy effects are activated separately for each material. Please also note that the *Gravity* panel only defines the direction of the gravity vector, but its effect won't be included in the calculation unless buoyancy is explicitly turned on in the *Buoyancy* panel.
3. ***Cavitation*** — Apart from the passive scalar VOF, an active scalar called CAV and its boundary conditions are turned on automatically and their properties may need to be redefined. If your problem involves only liquid and vapour, it is advisable to switch off the 'Free Surface' option in the 'Select Analysis Features' panel.
4. ***Transient load steps —*** These remain available in pro-STAR v3.20 but will eventually be phased out in favour of transient tables. Users are advised to build any new transient analyses on the basis of tables. Transient output values and controls that are new to pro-STAR 3.20 have not been generally made available using old-style load steps.
5. ***Transient output control*** — pro-STAR 3.20 uses time units to specify the frequency of data output to files `.pstt` whereas earlier versions use number of time steps. Thus, when resuming from an old model file, the new-style output frequency cannot be calculated if the time step size is not known.
6. ***Mixing vessel problems*** — Commands MIXASI and MIXVESSEL are still employed for automatic event generation in mixing-vessel type problems but they now require the definition of time 'periods' instead of the previous practice of defining load steps. The use of load steps with these commands is still possible if, after they are issued, the user proceeds to set up the intended load steps from scratch.
7. ***Command scripts*** — The end-result of v3.20 command scripts may differ from that of the equivalent v3.15 commands, even after all changes in parameters outlined in Appendix A have been implemented. Users should therefore check their models carefully to see if any corrective action is needed.

4.2 Known Issues

Liquid films

The SMAP operation does not work for liquid films.

Transients

1. In the “Analysis Output” panel (“Transient” Tab), the scroll list jumps after each selection
2. The TSMAP operation, used in transient cases restarting from a refined grid, does not work at present

HiRes screen dump

Produces binary postscript files that may not work on old printers

StarWatch

StarWatch does not monitor the new field variables introduced with v3.2 (e.g. Eulerian two-phase, Reynolds Stress and V2F turbulence models) nor does it allow you to change the parameters relating to these variables. For the older (v3.15) set of variables, it works on all platforms. It can also be implemented without any editing of the `/etc/services` file. In parallel runs, it is possible that the STAR job may hang or crash when the user updates the control variables.

At present, the default setting for STAR runs is for StarWatch to be switched off. Type `star -watch` if you want to turn it on.

Port-specific Issues

1. Linux ports — Linux/Motif has problems with diamond shaped toggle buttons. If the user selects a diamond-shaped toggle button option in pro-STAR, does not save this setting, goes to another panel and then back to the original panel, the setting of the toggle button goes back to the previous saved value, and the user cannot select this toggle button option again.
2. The Sun pro-STAR port does not allow the user to cut and paste inside user defined panels and may cause the program to crash. Any task that brings up the file selection dialog will crash if the user logs in with any of the following setups:
   en-US
   en US.ISO08859 1
   en US.ISO08859 15
   It works for C POSIX and this is the environment recommended by SUN.

5. STAR Features

5.1 STAR-PNP (Plug & Play)

A new methodology, called STAR-PNP, has been developed for running STAR v3.20 (see also Chapter 2, p. 2-5 in the User Guide). STAR-PNP is a completely new approach to running STAR that removes the distinction between sequential, parallel and batch runs. This works by automating the majority of tasks the user had to perform to set up sequential and parallel runs in previous STAR versions. For instance, the `starlink` utility is no longer required as there is no longer a need to create an executable, even in cases requiring user coding. For parallel runs, the Pro-HPC interface is no longer required. There is also no need to employ separate geometry decomposition or split/merge tools as these are now fully automatic. Note that you must start your job from an NFS disk that is accessible by all the nodes. The STAR solver is supplied as a number of objects which are automatically loaded as required and any user coding is automatically compiled, building a new

loadable object.

The installation structure is also different from STAR v3.150A and older versions. The STAR v3.20 installation consists of separate components for FLEXLM, MPICH, pro-STAR, STAR and STARNET, each with its own version numbers. The versions selected are defined by running the initialization command for each shell that needs to run STAR-PNP. Thus, there is no need to set a STARDIR environment variable as the correct components are accessed through a set of Dynamic Symbolic Links (DSL). The STAR solver is STAR-NET 3.0 compliant and will automatically recognize the Dynamic Node Allocation (DNA) assigned by resource managers supported by STAR-NET.

With this new methodology, users now only need to type "`star`", perhaps followed by a number of options if necessary, to run a case. STAR-PNP will automatically detect the main features of the case (e.g. moving mesh, user coding, etc.), and take appropriate actions. For example, to run a case using four processors on the local machine, all that is now needed is to enter

```
star 4
```

STAR-PNP will automatically decompose the mesh, copy all necessary files, deal with any user coding, and start the STAR job. If the same case was to be run across two host machines, the command would take the form

```
star host_name1,2 host_name2,2
```

There are several options available to the user which can be found in Appendix H of the User Guide, or by typing "`star -help`" at the command prompt.

5.2 Dynamic Memory Allocation

STAR v3.20 uses dynamic memory allocation, which means that a Fortran compiler is no longer required unless user coding is present. Existing user coding may require some modification, as described in Section 9 of these Release Notes.

5.3 STAR-Launch

STAR-Launch is a GUI providing easy access to STAR-CD components (see Chapter 2, "Using STAR-Launch" in the User Guide). STAR-Launch can launch the pre- and post-processing tools and run the CFD solver using STAR-CD's PNP features.

STAR-Launch can be activated by either typing

```
starlaunch
```

in your window's command line or clicking the STAR-CD icon on your desktop. Clicking the icon will activate STAR-Launch on the local machine only. Currently this icon is supported for the following operating systems:

- Linux running KDE and Gnome
- HPUX, AIX, Solaris and OSF1 running the Common Desktop Environment

Your systems administrator will install the STAR-Launch software in the STAR-CD installation directory but users may need to install the STAR-CD icon for their own desktop environment. The following three possibilities exist for installation of the icon:

1. The systems administrator can arrange for the STAR-Launch icon to be installed automatically during the STAR-CD software installation stage (see the Installation

and Systems Guide). A STAR-CD icon will then appear automatically on every desktop when the user runs STAR-Launch for the first time.

2. If the software administrator does not provide for automatic installation of the icon, users will be asked if they want to install it on their desktop when they run STAR-Launch for the first time.
3. The user can install the icon at any time by typing
   `starlaunch -icon`

To uninstall the STAR-CD icon from your desktop, type
`starlaunch -noicon`

5.4 Eulerian Two Phase

STAR v3.20 marks the first release of Eulerian two-phase modelling as a fully supported feature. Laminar and turbulent, thermal and isothermal flow calculations are possible on all mesh types, using the SIMPLE solution algorithm for steady-state and pseudo-transient simulations, and the PISO algorithm for transient simulations. The two phases can be gaseous, liquid, or solid, without restriction on the range of volume fractions. The phases are coupled through momentum and heat exchange terms that are calculated from a range of submodels, including ones supplied via user coding. Special, application-specific models are provided for granular flows, with added inter-granular stress terms. For bubbly flows, new degassing (or escape) boundary conditions have been implemented. Thermophysical fluid properties may vary according to a range of options, including user coding. Further details are given in Chapter 13 of the Methodology volume and Chapter 14 of the User Guide.

5.5 Turbulence Models

The following new turbulence models have been included in STAR v3.20 (see also Chapter 2 in the Methodology volume):

- Reynolds Stress model: This is available in two versions, the standard Gibson-Launder model and the Speziale-Sarkar-Gatski model. This type of model is useful for capturing complex effects arising from anisotropy, curvature, swirl and rotation in the flow field.
- V2F model: This has attracted considerable interest over the past few years due to its success in predicting a wide range of flow features, especially near walls.
- k-ε Suga non-linear model: This offers a more accurate treatment of turbulence at stagnation and separation regions compared to the standard non-linear k-ε model.
- k-ω and k-ω SST models: These are particularly useful when calculating separation and also for flows in adverse pressure gradient regimes.
- Spalart-Almaras model: This combines low CPU costs with reasonable accuracy, and is especially useful in external aerodynamics applications.

5.6 Wall Functions

The following new features are included in this release (see also Chapter 6 in the Methodology volume):

- Hybrid wall functions are available that extend the low-Reynolds number formulation of k-ε, k-ω and Spalart-Almaras turbulence models. These may be used to capture boundary layer properties more accurately in cases where the

near-wall cell size is not adapted for the low-Reynolds number treatment and thus achieve y^+ independent solutions.
- A new non-equilibrium wall function suitable for flows with non-zero pressure gradients.

5.7 Combustion Models

Several new combustion features are supplied, as follows:

- A complex chemistry model that can handle multiple step reaction systems with detailed reaction mechanisms. This model solves transport equations for all chemical species and takes into account the preferential diffusion of each species.
- A Laminar Flamelet model that takes into account non-equilibrium effects and multiple reaction steps in non-premixed combustion.
- The Weller 2- and 3-equation models for premixed and partially premixed combustion, respectively. Unlike the Weller 1-equation model, these models account for non-equilibrium effects by solving a transport equation for the wrinkle factor.
- A soot model to calculate soot production in engines and diffusion flames.
- A multi-fuel PPDF model that handles non-premixed combustion of two different fuels.
- Ability to define two different ignitions.
- An option to use the heat of reaction for relevant combustion models.

Further details are given in Chapters 10 and 11 of the Methodology volume and Chapter 12 of the User Guide.

5.8 Material Properties

Additional polynomial forms are available for thermal conductivity, molecular viscosity and diffusivity, plus an option to calculate them using kinetic theory (see Chapter 1, “Mixture properties” in the Methodology volume.

5.9 Lagrangian Two-phase Flow

Major developments in this area are:

- Heat transfer between wall-adhering droplets and the wall boundary can now be accounted for.
- The turbulent dispersion model has been re-implemented and enhanced. Generally, particle diffusivities will be higher than in previous versions of STAR.
- Probability density functions can be used to generate droplet diameter distributions for explicitly-defined parcel injection.
- Collision model: A faster collision algorithm has been implemented for the O’Rourke model, along with several options for improved modelling. These include a user-definable collision detection method, an optional coalescence timescale and a cell clustering methodology for optimising the computational effort required in detecting inter-droplet collisions. Note, however, that in HPC runs such clusters should not straddle inter-processor boundaries.

Further details are given in Chapter 12 of the Methodology volume and Chapter 13 of the User Guide.

5.10 Liquid Film Modelling

A new liquid film model allows for convection within the film, mass transfer with the gas phase, and momentum and heat transfer with the walls and gas phase (see also Chapter 16, “Liquid Films” in the Methodology volume and Chapter 17, “Liquid Films” in the User Guide). Films can be formed by droplet impingement or can be present as an initial condition (the latter is currently a Beta feature)

5.11 Free Surface and Cavitation

Major developments in this area are:

- VOF heat transfer: This feature has been enhanced to include conjugate heat transfer between fluids and solids, plus variable specific heat capacities and thermal conductivities for both phases. It also includes heat transfer in cavitating flows.
- Cavitation: The Rayleigh model has been added to the cavitation model suite. Both two-fluid (liquid and vapour) and three-fluid (liquid-gas-vapour) cavitation modelling is available.
- Free surface with surface tension: The surface tension model was extended to enable users to define a contact angle at wall boundaries. Both the surface tension coefficient and the wall contact angle may be specified in any manner through user coding.
- Other VOF extensions: Free surface/cavitation modelling in non-Newtonian fluids or within porous media are now available.

Further details are given in Chapter 14 of the Methodology volume and Chapter 15 of the User Guide.

5.12 Engineering Data Output

The ability to monitor engineering data during the course of the analysis via the `case.erd` file has been extended. Data can now be monitored at virtual surfaces within the solution domain in addition to standard boundary regions (see “Internal Regions” on page 7-40 of the User Guide for more information).

5.13 Boundary Condition Enhancements

Major developments in this area are:

- Riemann Invariant condition: A new boundary condition useful in external aerodynamics simulations. Its application allows pressure waves to leave the solution domain without reflection.
- Radial-equilibrium pressure boundary: A new boundary condition useful in turbomachinery applications.
- Non-reflecting boundaries: A set of these (pressure, stagnation, and mixing-plane types) may be used to improve the accuracy of steady-state simulations in cases where strong pressure waves leave the solution domain.
- Boundary values of turbulence parameters (in terms of k/epsilon, turbulence intensity/mixing length or Reynolds Stress components) can now be specified per boundary region.
- The stagnation boundary condition has been extended to accept stagnation quantities in either an absolute or a rotating frame of reference.

Further details are given in Chapter 5 of the Methodology volume and Chapter 7 of the User Guide.

5.14 Anisotropic Conductivity in Solids

Thermal conductivity in solid materials may vary according to coordinate direction (see “Conduction and conjugate heat transfer” on page 1-6 of the Methodology volume for more information).

5.15 Tables for Sources and Initialisation

STAR v3.20 will accept mass, momentum, energy and scalar sources defined using tables associated with materials or cell types. Tables can also be used to initialise field data in a similar way (see Chapter 2, “Table Manipulation” in the User Guide for further details).

5.16 Radiation Features

Major developments in this area are:

- A new radiation modelling capability based on the Discrete Ordinates method has been implemented. Further details are given in Chapter 9, “Radiation in Participating Media” in the Methodology volume and Chapter 2, “Radiation Modelling Using Discrete Ordinates” in the User Guide.
- For the non-participating Discrete Beam radiation model, users can now
  (a) Obtain detailed information on radiative heat transfer between boundary regions
  (b) Print information about those patches that contribute most of the incident radiative heat flux on a specified patch

6. STAR Beta-level Features

A number of CFD modelling facilities are available on a Beta-level basis. Outline descriptions, plus instructions on how to use them are given in the Supplementary Notes document. These features are listed below:

- Radiation model extensions
- Detached Eddy simulation
- Advanced free surface modelling
- Droplet break-up models
- The coal blend combustion model
- Turbulence effects in Complex Chemistry models
- User-defined thermal diffusion coefficient

7. Code and File Structure Changes

Significant changes have been made to files created by STAR and pro-STAR, as follows:

- As the `.pstt`, `.rpo`, `.err` and `.terr` file formats have changed, such files created under STAR v3.15 cannot be appended by STAR v3.2. Therefore, such files should be deleted or re-named.
- STAR v3.20 will read a v3.15 `.pst` file for restart purposes, but the new `.pst` file written by STAR v3.20 can be only be read by pro-STAR 3.2.

- In moving mesh applications, grid-changing command files must always have a `.cgrd` file extension.
- The structure of both `.geom` and `.prob` files has changed since v3.15; such files should not be used in v3.2 runs.

8. Use of Switches and Constants

A number of 'new' features were supplied in the past as Beta features and were used under v3.15 via pro-STAR Switches and Constants. Users resuming from a v3.15 model file will find that these Switches and Constants are now reset automatically to their correct setting. However, users should still check the problem setup in case any settings have been missed.

9. Important Notes for STAR

9.1 Changes of Practice

Stagnation boundary conditions

(a) Turbulence effects are included in the definition of stagnation quantities. If the user so wishes, these may still be removed by turning on Switch 83.

(b) Stagnation quantities and velocity direction are now decoupled:

i) The velocity direction definition follows what has been specified in pro-STAR in the past. The stagnation quantities are defined in an absolute frame of reference by default.

ii) To obtain the same behaviour as in v3.150A (Patch 16 onwards), please set the *Stag. Quant.* option to **Relative** when choosing **Relative** for the *Velocity* option, together with **Specify** for the *Direction* option

Lagrangian multi-phase cases

(a) The default interpolation method for calculating continuous-phase temperature, velocity and species mass fractions at droplet locations has changed, from using cell data to using gradients (see page 12-31 in the Methodology volume).

(b) The default numerical algorithm for calculating droplet source terms for the gas phase is the same as in v3.15 and is referred to as 'Standard'. An under-relaxation factor can now be specified via pro-STAR (in v3.15 the default under-relaxation factor was 1.0, with alternatives being supplied by RCONS(34).

(c) File `.spd` can be written without a SPEED license; it will be created automatically for cases involving either Lagrangian two-phase flow or certain combustion models. A separate `.spd` file will be written for each fluid stream.

(d) For HPC runs, injector information will be written to the `.info` files on all nodes; the droplet balance data which will be written only to the master node's `.info` file. All droplet information found in that file will appear in the merged `.info` file. The `.spd` files found in the master directory contain global information and are copied to the top directory at the end of the run.

(e) The droplet condensation model is switched off by default (former Switch 199 in v3.15).

(f) In STAR v3.15 spray models, the user was able to specify the fuel type injected

(N-Heptane, N-Dodecane or HMN). The user also had to select “User coding” for the droplet properties (subroutine DROPRO) and call an internal function (FUELFN) from within the user code. In the equivalent STAR v3.2 setup, the droplet properties are set to “Droplet properties will be calculated internally by STAR” and user subroutine DROPRO is no longer needed since function FUELFN is automatically called by STAR.

To call function FUELFN from the DROPRO subroutine in STAR v3.20, variable IFTYPE should be set inside the subroutine as follows:

i) IFTYPE = 1 for N-Dodecane
ii) IFTYPE = 2 for N-Heptane
iii) IFTYPE = 3 for HMN

Numerical methods

The Gamma convection discretization scheme is no longer supported. For equivalent functionalities and capabilities, please choose the MARS scheme.

STAR output

(a) When reporting the CPU time in the `.run` and `.info` files, the code now also reports the amount of dynamic memory used (in Mbytes). However, this figure does not include static arrays or RAMFILES.

(b) For STAR-HPC runs, cell data from each domain are merged into the `.run` and `.info` files for the whole model.
Note that the cells are listed under a DOMAIN header and in the order in which they appear within each domain. The order in this listing is thus different from the one that would be produced if the model was run in sequential mode.

Free surface flows

For free surface calculations, the time step required to solve the VOF transport equation is typically smaller than that required for the other transport equations. STAR predicts the time step size required for VOF transport based on the free surface progress. In Figure 1, this time step is labelled as DTFS. In order to avoid solving all other transport equations with this small time step, it is possible to use a form of “subcycling” (see the User Guide and Methodology volumes) where several VOF calculations are performed before solving the other transport equations. The user can set the maximum number of subcycles in pro-STAR. DTFS will remain constant during multiple VOF calculations.

However, it is possible for the time period given by the product of DTFS and the ‘maximum number of subcycles’ value to be less than the original time step specified by the user. If this happens, a substep period is introduced (as shown in Figure 1) which has a time period of (DTFS * No. of subcycles). This substep time is used to solve all other transport equations (thus completing a PISO loop). Several substeps may be required before the original user time step is complete.

Essentially, the substep is the true time step driving the overall solution. The original time step specified by the user is now only used to determine the points at which data should be written to the `.pstt` file. The user time step will be taken into account if the user attempts to ABORT a free surface calculation, as the code will continue running until the end of the user time step before it stops. The overall calculation time will also be set by the user time step.

The `.info` file will now show data on substeps within the normal user time step. The

number of VOF calculations (subcycles) is also shown in the `.info` file.

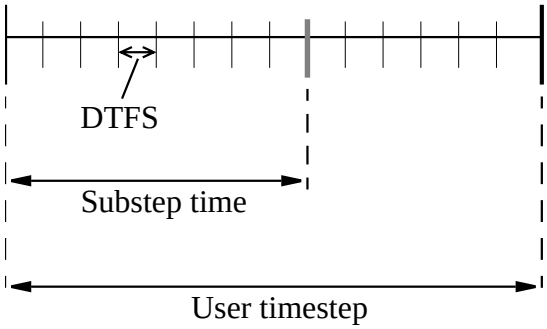

Figure 1 Illustration of the new practice in free surface flows

The STAR Toolchest

This release supports the new Toolchest approach for interaction with other codes, such as es-tools. Whereas previously this interaction would have taken place through user subroutines, STAR now supports “plugins”, i.e. pre-compiled code that becomes part of STAR’s Toolchest library.

Material properties

The material properties database (`props.dbs`) now contains separate entries for commonly occurring fluids that may be present in either the liquid or the vapour (gaseous) phase in a CFD model. A suffix `_l` is added to the chemical formula of liquid substance entries so that the code may correctly distinguish between the two property sets.

Radiation

The heat source to be added to the enthalpy equation due to participating media radiation is now always subject to a non-linear treatment. In v3.15 this treatment was a user-selectable option determined by the ‘Enthalpy Treatment’ setting in the ‘Thermal Options’ panel. In v3.2 it is not possible for users to choose otherwise as this treatment leads to more accurate results.

Wall heat transfer

The local heat transfer coefficient on a wall boundary is now calculated using the specific heat instead of the mean specific heat as in previous versions of the code. Differences may be observed when variable specific heat is chosen for material properties. Switch 31 can be used to revert to the previous practice (mean specific heat).

9.2 Known Issues

General issues

1. The following features are not currently available under the STAR-CD 3.20 solver:

   (a) Chemical reactions using STAR/KINetics (deferred to release v3.22)
   (b) The GT-POWER interface (deferred to release v3.24)
   (c) Fluid-Structure interaction under the MpCCI code coupling interface (deferred to a future STAR-CD release)

2. There are four known issues with thermal radiation:

   (a) The transmissivity for external walls must be set to 0. External walls are all walls except conducting walls adjacent to solid-fluid interfaces.
   (b) At conducting walls (solid-fluid interfaces), the transmissivity at the solid-fluid interface must be either 1 or 0, depending on whether radiative heat transfer through the solid material is to be considered. If radiation in the solid is on, the transmissivity at the solid-fluid interface must be 1, otherwise it must be 0.
   (c) The discrete ordinates method may cause the warning

   ```
   .. Freeing unrecognized pointer
   ```

   to be written to the screen. This can be safely ignored.
   (d) In discrete ordinate analyses which involve partial domain radiation, fixed heat flux boundary conditions should not be used on portions of the domain not involved in the radiation calculation.

3. The following issues concern liquid films:

   (a) Droplets impinging on a film are not converted to film if the Lagrangian two-phase solution procedure is set to Predictor Only.
   (b) At present, momentum transfer will always be active for liquid films (i.e., the setting specified in pro-STAR has no effect).
   (c) Coupling between liquid film and gas phase follows the Lagrangian two-phase setting. Switch 123 can be used to decouple the liquid film from the gas phase when the Lagrangian two-phase option is inactive.
   (d) Liquid-film wall data do not appear in the `.run` file even when the user has specifically requested them

4. When using the Crank-Nicholson time discretisation scheme, the mass, energy and species fluxes appearing in the `.info` file are reported on the basis of the fully implicit scheme's differencing 'molecule', not the correct Crank-Nicholson 'molecule'.
5. The non-adiabatic implementation of the PPDF combustion model may not give accurate results as far as species mass fractions are concerned. Work is in progress to rectify this by modifying the code to compute both species mass fractions and temperature from the enthalpy obtained from the transport equation solution. The modification will also allow treatment of multiple air or fuel inlets with the same composition but different temperatures using a single mixture fraction. For streams of different composition, however, the multi-fuel PPDF option should be used instead.
6. Rotating reference frame cases using a Reynolds Stress turbulence model fail to converge.
7. When the k-ω SST model is applied to cases involving heat transfer in impinging flow regions, the calculated heat transfer coefficients do not agree with experimental results at present.
8. The AMG solver requires that all mesh regions associated with a given material are connected.
9. A number of spray and wall collision models previously available under a SPEED license still require this license in order to run. This limitation will be removed by the time of the next STAR-CD interim release.

General HPC issues

1. STAR-HPC runs are not feasible for problems involving participating media or solar radiation.
2. Currently the AMG solver can run with a maximum of 256 processors.
3. STAR-PNP supports the following queuing systems: LSF, OpenPBS and Sun Grid Engine. Users needing this facility should contact CD adapco for the relevant details.
4. The following issues concern parallel runs of Lagrangian two-phase cases:

   (a) When merging the `.pst/.pstt` files of transient runs, some droplets may be reported as lost. This is not in fact the case and if the individual `.pst/.pstt` files are separately loaded from each sub-domain, the droplets' correct status and properties can be displayed. This problem will be resolved by the time of the next interim release.

   (b) For cases where the number of parcels is approximately equal to or greater than the number of cells, the following message may appear on screen

   ```
   ...out of space on attached buffer...
   ```

   and the run subsequently stops. This is related to the MPI implementation being used. If you encounter this problem please contact CD adapco's User Support for information on how to overcome it.

Port-specific HPC issues

1. Cases running on HP-UX Itanium platforms with MPICH and the Shared Memory Communication device are unreliable and may fail. If a problem occurs, HP Itanium MPI should be used instead.
2. Lagrangian multi-phase cases running on IRIX MIPS platforms using the SGI MIPS MPI may lose droplets as they pass between sub-domains. If such a problem is encountered, MPICH should be used instead.
3. Lagrangian multi-phase cases running on OSF1 Alpha platforms using HP Alpha MC MPI may fail with a segmentation fault. If such a problem is encountered, LAM MPI or MPICH should be used instead.
4. Linux runs using the default geometry decomposition method (Metis) decompose the model in a different way to that of other platforms. This may produce results and convergence behaviour that are different to those for other platforms.
5. The Discrete Ordinates radiation model does not work correctly in HPC mode for the OSF1 and HP-UX platforms.
6. If you are using Sun MPI on a single host which has been configured as part of a Sun cluster, please use the STAR-PNP `-noshmem` option to force STAR to run on the correct machine. The run may ramdonly fail otherwise.

Other port-specific issues

1. Users of IRIX MIPS systems prior to 6.5.19f should note that problems may be encountered compiling user subroutines if these subroutines reside on a file system NFS-mounted from Solaris systems and certain Linux system (all Reiserfs file systems and ext3 on SuSE 8.2).
2. STAR-Launch may hang on start-up if the user's home directory resides on a disk mounted on a Solaris 5.7 system.

10. User Coding

Most standard user subroutines from Versions 3.15 and 3.15A will require no modification for Version 3.20. Exceptions to this rule are noted below.

10.1 New User Subroutines

The following subroutines are introduced in this version:

BCDEFR: Boundary condition definition for Riemann invariant boundaries
BCDNRP: Boundary condition definition for non-reflecting pressure boundaries
BCDNRS: Boundary condition definition for non-reflecting stagnation inlets
COALC: User char combustion model
COALV: User devolatilisation model
COLLDT: Detect whether a collision occurs or not
COLLND: Calculate droplet number density for collision calculations
DROBRK: Droplet break-up
FDBRK: Film/droplet secondary break up model
FSEVAP: Rate of evaporation/condensation in free surface flows
FSTEN: Surface tension and contact angle in free surface flows
LFPROP: Liquid film physical properties
PARUSR: User particle source
RADMAT: Radiation band properties (Discrete Ordinates Radiation)
RADREG: Non-grey boundary properties (Discrete Ordinates Radiation)
RATUSR: Turbulence effects in complex chemistry models
REACUL: Chemical reaction rates for complex chemistry models
THDIFF: Coefficient of thermal diffusion
UEDRAG: Specify drag force (Eulerian Two-Phase)
UEHEAT: Specify Nusselt number (Eulerian Two-Phase)
UETURB: Specify turbulence response function (Eulerian Two-Phase)

10.2 Removed User Subroutines

OMGDEF has been removed. Its functionality is now combined with UOMEGA
UFDE2P has been replaced by UEDRAG and UETURB

10.3 Modified User Subroutines

None of the internal variables in existing user subroutines have been renamed or removed. However, some subroutines take modified arguments, as follows:

v3150A: BCDEFF(UINF,VINF,WINF,PINF,TINF)
v3200: BCDEFF(UINF,VINF,WINF,PINF,TINF,TEINF,EDINF)

v3150A: BCDEFI(SCALAR,U,V,W,TE,ED,T,DEN,TURINT)
v3200: BCDEFI(SCALAR,U,V,W,TE,ED,T,DEN,TURINT,RSU,V2P,F2P)

v3150A: BCDEFP(UB,VB,PR,TE,ED,T,SCALAR,TURINT)
v3200: BCDEFP(UB,VB,WB,PR,TE,ED,T,SCALAR,TURINT)

v3150A: BCDEFT(UINF,VINF,WINF,PINF,TINF)
v3200: BCDEFT(UINF,VINF,WINF,PINF,TINF,TEINF,EDINF)

v3150A: CAVPRO(AL,AV,PV,SIGMA,CONTANG)
v3200: CAVPRO(AL,AV,PV,TSAT,HVAP)

v3150A: CONDUC(CON)
v3200: CONDUC(CON,CKNX,CKNY,CKNZ)

v3150A: DROPRO(DENDR,CPDR,HV,PS,SFTC,DRVIS)
v3200: DROPRO(DENDR,CPDR,HV,PS,SFTC,DRVIS,DRCOND)

v3150A: FLUINJ(FLUXI,UI,VI,WI,TEI,EDI,TI,SCINJ)
v3200: FLUINJ(FLUXI,UI,VI,WI,TEI,EDI,TI,SCINJ,IPMASS)

v3150A: INITFI(U,V,W,PR,TE,ED,T,SCALAR)
v3200: INITFI(U,V,W,PR,TE,ED,T,SCALAR,XVF2)

v3150A: UOMEGA(AMBND,OMEGA)
v3200: UOMEGA(MAT,OMEGA)

Also note the following:

v3150A: POSDAT argument RESOR had dimensions (63,-100:100)
v3200: POSDAT argument RESOR has dimensions (89,-100:100)

The critical changes are BCDEFP, CAVPRO and UOMEGA. It is mandatory to upgrade these subroutines to reflect the modified arguments or functionality. It is also advisable to upgrade the remaining subroutines in the list above to make use of the extra arguments.

A number of subroutines have extra functionality as a result of introducing the Eulerian Two-Phase capability. Please consult Chapter 18 of the User Guide for more information.

10.4 Guidelines for Upgrading User Subroutines to Version 3.2

The following steps are recommended when upgrading user subroutines to the current version:

- Ensure the subroutine is still supported (see above)
- Ensure the arguments are complete and correct (see above)
- If the subroutine contains user-defined arrays with case-dependent size, it will need modification
- If the subroutine makes use of any STAR common blocks, it may need modification.

The reasons for the last two steps are:

- STAR v3.2 uses dynamic memory
- Some of STAR’s common block names have been changed

User Defined Arrays

Regarding the declaration and use of arrays, no action is necessary when the arrays have

fixed size, e.g.

```
DIMENSION AUXVEL(3)
```

For arrays whose size depends on model parameters (e.g. number of cells), consult section “New Coding Practices for Dynamic Memory” in Chapter 18 of the User Guide.

STAR Defined Arrays

Please contact User Support for the new names of STAR common blocks and additional information about changing these blocks to use dynamic memory. As an example of the dynamic memory style of common blocks, the new way of referring to the array

U(3,-NBMAX:NCMAX)

is:

```
POINTER(P_U,U(3,-NBMAX:NCMAX))
COMMON /DCO2C/ P_U
```

It is no longer necessary to include file `parm.inc` to access NBMAX and NCMAX.

11. User Documentation

As usual, all documents are accessible either from the pro-STAR Help menu (including on-line versions of the hard-copy manuals) or from STAR GUIde’s Help button (for context-sensitive On-line Help topics). In addition, most documents are also accessible from the STAR-Launch Help menu, option “STAR-CD Manuals”.

Appendix A of this document contains a list of all significant changes to the pro-STAR command set since Version 3.15A.

Appendix A Summary of Command Changes

As a result of changes to the code, some commands have been created while others have been modified or deleted. The following table provides a summary of all changes since Version 3.15A. Where modifications are involved, changes are further classified as:

- **Critical Modification** — meaning that old command files containing this command need to be edited in order to work properly
- **Name Change** — a special category of modifications, where the only change is a different command name
- **Non-critical Modification** — additions/changes have been made to the command parameters or functionality but old files should still work unchanged
- **Default Change** — the default values of some command parameters have changed. Depending on how the command was used, this may amount to a critical or non-critical modification

Detailed descriptions of the new commands are given in the Commands volume.

Table 1-1: List of New, Modified and Deleted pro-STAR Commands

Module	Command	Status					
		New	Name Change	Critical Modification	Non-critical Modification	Default Change	Deleted
PRO	FEXTENSIONS						•
	FSCAN						•
	GEOMWRITE				•		
	GETFILE						•
	SAVE				•		
	WIPEOUT	•					
	*CALC				•		
	*GET				•		
MESH	CHECK				•		
	CMREFINE			•			
	CMUNREFINE			•			
	CPARBITRARY						•
	CPCREATE	•					
	CPMATCH						•
	CPMERGE				•		

Module	Command	Status					
		New	Name Change	Critical Modification	Non-critical Modification	Default Change	Deleted
	CPREAD				•		
	CPSET			•			
	CPTABLE			•			
	CPTMODIFY			•			
	CTNAME					•	
	VCROSS				•		
	VMAP				•		
	VSCALE				•		
CONVERT	CGNS				•		
	ICEM	•					
	PSTAR						•
	TSTAR						•
PLOT	ARROW				•		
	BDISPLAY			•			
	BSET				•		
	CSCALE				•		
	EDGE (formerly EDGESEL)		•				
	HRSDUMP	•					
	LAYER	•					
	PLMESH				•		
	RENDEROPT	•					
	SCENE	•					
	SETADD				•		
	SURFACE (formerly SURFSEL)		•				
	VIEW				•		

Module	Command	Status					
		New	Name Change	Critical Modification	Non-critical Modification	Default Change	Deleted
UTILITIES	COUNT				•		
	MCALCULATE						•
	SMAP			•			
	TSMAP			•			
PROPERTY	ACCELERATION			•			
	BUOYANCY	•					
	COKE			•			
	COLES					•	
	CONDUCTIVITY				•		
	CONL			•			
	DENSITY				•		
	DIFCORRECTION	•					
	DIFFUSIVITY	•					
	INISCALAR	•					
	INITIALIZE			•			
	LVISCOSITY				•		
	MOLWT	•					
	NWALL	•					
	PMATERIAL				•		
	POLENTHALPY	•					
	POLSCALAR	•					
	POPCP			•			
	POPD	•					
	POPK			•			
	POPLV			•			

Module	Command	Status					
		New	Name Change	Critical Modification	Non-critical Modification	Default Change	Deleted
	POROSITY (formerly POROUS)		•				
	RSOURCE			•			
	SCPLIST				•		
	SCPMODIFY						•
	SCPROPERTIES			•			
	SCSOURCE	•					
	SHTRA	•					
	SPECIFICHEAT				•		
	SPIN				•		
	SRCLIST	•					
	THERMDIF	•					
	TUGL	•					
	TUSSG	•					
	WALLFUNCTION	•					
SCALAR	POSCP			•			
	POSD	•					
	POSK			•			
	POSLV			•			
	SC				•		
BOUNDARY	BDELETE				•		
	BPATCH				•		
	BPCOMPRESS	•					
	BREAD				•		
	BZONE				•		
	CICDEFINE	•					

Module	Command	Status					
		New	Name Change	Critical Modification	Non-critical Modification	Default Change	Deleted
	CICOMPRESS	•					
	CIDELETE	•					
	CILIST	•					
	CIMM	•					
	CITAG	•					
	MPCCI	•					
	RDEFINE			•			
	RINLET			•			
	RTPRESSURE			•			
	RTURBULENCE	•					
CONTROL	AAANALYSIS	•					
	BRMONITOR				•		
	CAVITATION			•			
	CAVNUCLEI	•					
	CSMONITOR				•		
	DSCHEME			•			
	EDATA	•					
	FLUINJ						•
	FSDSCHEME			•			
	FSMASSTR	•					
	FSSUBCYCLE					•	
	FSURFACE			•			
	LESOUT					•	
	MFRAME				•		
	PANALYSIS	•					
	POWALL			•			
	PRCHECK				•		

Module	Command	Status					
		New	Name Change	Critical Modification	Non-critical Modification	Default Change	Deleted
	PRWALL			•			
	RADIATION			•			
	RDATA			•			
	RELAX				•		
	RESIDUAL				•		
	SCCONTROL					•	
	SOLAR			•			
	SOLVE				•		
	STENSION	•					
	SWEEP				•		
	VAPORIZATION	•					
	WHEATTR	•					
TRANSIENT	CPOST				•		
	CPRINT				•		
	DELTIME	•					
	ECPOST	•					
	ECPRINT	•					
	MVGRID				•		
	PRPOST	•					
	RUNTIME	•					
	TRELATION	•					
	WRPOST	•					
DROPLETS	DCOLLISION			•			
	DCONDENSATION	•					
	DINTERPOLATION	•					
	DMAX					•	

Module	Command	Status					
		New	Name Change	Critical Modification	Non-critical Modification	Default Change	Deleted
	DRBOIL			•			
	DRCREATE	•					
	DRDIAMETER	•					
	DRFORCE	•					
	DRGROUP	•					
	DRNPROCEDURE	•					
	DRPMODE	•					
	DRPROPERTIES				•		
	DRSDUPLICATE	•					
	DRTYPE				•		
	DRUSER	•					
	DRWALL			•			
	FUEL			•			
	INJECTOR			•			
	PEMISSIVITY	•					
	SPRAY						•
	STPA	•					
LIQ. FILMS	LFBOIL	•					
	LFCMPONENT	•					
	LFCONDENSATION	•					
	LFFORCE	•					
	LFFUEL	•					
	LFHEAT	•					
	LFMASS	•					
	LFMMENTUM	•					
	LFMODEL	•					
	LFPROPERTY	•					

Module	Command	Status					
		New	Name Change	Critical Modification	Non-critical Modification	Default Change	Deleted
	LFSOLVE	•					
	LFSTRIP	•					
	LFTDELETE	•					
	LFTYPE	•					
EVENTS	EASI			•			
	EVMGRID						•
	MVGRID			•			
CHEMICAL	CHEREACTION	•					
	CHMSOLVER	•					
	CKBREGION	•					
	CKCTABLE	•					
	CKELEMENT	•					
	CKFO	•					
	CKGOPTION	•					
	CKIN	•					
	CKLIST	•					
	CKMAT	•					
	CKPOST	•					
	CKPREP	•					
	CKREACTION	•					
	CKRO	•					
	CKSFRACTION	•					
	CKSOPTION	•					
	CKSPECIES	•					
	CKTHIRD	•					
	COMCHECK	•					

Module	Command	Status					
		New	Name Change	Critical Modification	Non-critical Modification	Default Change	Deleted
	COMSET	•					
	CRMODEL			•			
	DILUTANT	•					
	FLCO	•					
	FLCP	•					
	FLDELETE	•					
	FLGENERATE	•					
	FLKV	•					
	FLPLOT	•					
	FLR1	•					
	FLR2	•					
	GFTB	•					
	HRCO	•					
	IGN2	•					
	IGNMODEL			•			
	KNOCK			•			
	MIXFRACTION	•					
	NOX			•			
	REHT	•					
	SBREACTION	•					
	SOOT	•					
	TBIN	•					
	TWOIGNITION	•					
POST	GETBOUNDARY				•		
	GETCELL				•		
	GETUSERDATA			•			
	GETVERTEX				•		

Module	Command	Status					
		New	Name Change	Critical Modification	Non-critical Modification	Default Change	Deleted
	GETWALL				•		
	OPERATE				•		
	PTOPTION	•					
GRAPH	EDGRAPH				•		
	EDLOAD				•		
	GDATA			•			
	GMARK			•			
	GPOST				•		
	GRDISPLAY			•			
	GTRANS			•			
EULERIAN	EBODY	•					
	EBRMONITOR	•					
	ECNDUCTIVITY	•					
	ECSMONITOR	•					
	EDENSITY	•					
	EDRAG	•					
	EEDGRAPH	•					
	EEDLOAD	•					
	EGEBOUNDARY	•					
	EGECELL	•					
	EGEVERTEX	•					
	EGSTAR	•					
	EGTRANS	•					
	EHTRANSFER	•					
	EINIT	•					
	EINTERNAL	•					

Module	Command	Status					
		New	Name Change	Critical Modification	Non-critical Modification	Default Change	Deleted
	ELVISCOSITY	•					
	EMOLWT	•					
	EMOMENTUM	•					
	EMPHASE	•					
	EPCP	•					
	EPHASE	•					
	EPLIST	•					
	EPLV	•					
	EPOK	•					
	ERDEF	•					
	ERELAX	•					
	ERESIDUAL	•					
	ERLIST	•					
	ERMODIFY	•					
	ERTPRESSURE	•					
	ESIZE	•					
	ESOLVE	•					
	ESPECIFICHEAT	•					
	ESWEEP	•					
	ETEMPERATURE	•					
	ETURB	•					
RADIATION	VFCALC	•					

Appendix B Automatic Meshing — Version 3.20 Release Notes

Version 3.20 represents a new release of pro-am, containing new and improved existing features. The GUI options continue to be accessible via the AutoMesh pull down menu in the pro-STAR interface. Model and database files from the v3150A releases of STAR-CD and pro-am continue to be upwards compatible with this release and can be read via the new pro-STAR program.

New for release v3.20

As per all pro-am releases, the latest ammbatch program continues to improve the quality of the resultant meshes, especially in the area of trimmed cell meshes and templates with auto refinement. Other improvements and changes have been made in the areas of GUI support, surfacing, subsurface generation and extrusion mesh generation, as follows:

- New — Quad morpher for creating arbitrary quad shells, starting from a good- quality triangulated surface.
- New — The default subsurface generation scheme is Subsurface Method#8, which combines the advantages of previous methods #4 and #7. Methods #4 and #7 are now obsolete.
- New — The Mesh Wizard now allows all three mesh types to be generated. These types are trimmed (with refinements), tetrahedral and hybrid.
- New — Multiple tetrahedral regions with different cell types automatically allocated to each region.
- New — Batch-based hybrid mesher replaces the previous version. The hybrid mesh is now generated in one go and does not require a core mesh from a template.
- New — Extrusion layer generation is now fully automatic and does not require user interaction to create the extrusion surface.
- New — Specification of wall thickness of near wall cell layers.
- New — Specification of local surface properties for extrusion mesh generation, allowing the number of layers and grid spacing to be controlled on a surface-by-surface method.
- Improved — Surface wrapper with additional levels of control.
- Improved — CPmatch generation for trimmed cell meshes and reduction of unresolved cells for complex geometries.
- Improved and extended GUI panels for template mesh generation and extrusion layer generation.
- Improved — Documentation, including a new Advanced Mesh Wizard tutorial.

Previous Release Updates (in chronological order)

v3102.515 Updates

As of this date, we have found two problems that may be circumvented with user intervention. First, ammbatch organizes and labels integral and arbitrary CPmatches separately. When running the CPCHECK command on integral CPmatches, the tolerance for comparing the sum of the slave areas with the master area is quite tight. Even small amounts of warpage in the master face may throw off

this number slightly, resulting in large numbers of warning messages. This can be circumvented by either upping the TOLIN parameter of the CPCHECK command (perhaps to .1 instead of the .01 default) or by changing that number globally with the CPTOL command.

Second, when starting from a custom mesh that already has some CPmatches in it, under certain conditions, ammbatch may alter these CPmatches, ending up with an integral match with one master and only one slave. These will also be rejected by the CPCHECK command, but can be fixed using the following macro:

```
cpset,news,integral
cpset,subs,nslave,1
vset,news,cpset
vmerge,vset$n
cpdel,cpset
```

v3102.516 Updates

This release fixes the CPMATCH problems mentioned in the v3102.515 update above. It also takes care of various installation problems that affected some of the initial release CD's. With this version, pro-am and ProFE have been synchronized. Either program can be run from this same release.

Patch release 516 contains a new methodology for fixing unresolved cells in trimmed cell meshes. A panel called Remesh Region using TetFix has been specially developed to guide the user through a technique which can aid in the rapid fixing of problem areas. The panel is located in the Generate Mesh -> Mesh Tools set of menus. A full description of the method is contained in Chapter 6 of the User Guide and an example tutorial is provided in the Tutorial set.

A new, simple-to-use Surface Wrapping panel has also been developed — it is located in the Prepare Surfaces -> Create New Surfaces set of menus. A brief description of the panel is included in Chapter 4 of the User Guide.

A limited amount of Error Trapping has also been included in this release — please see Chapter 3 of the User Guide for additional details on this.

As with all releases, a small amount of label changes have been made to the panel to improve ease-of-use and general navigation. Current users should not have any difficulty in recognizing the new option names and changes.

v3102.517 Updates

v3102.517 was a request-only release containing bug fixes and some minor enhancements, which are documented in the v3102.518 section of this document.

v3102.518 Updates

Release v3102.518 contains mainly bug fixes to the ammbatch program and pro-am panel, as well as some minor enhancements. These include:

- The default extrusion algorithm has been replaced with a new one, which should produce better results for trimmed cell meshes with fine/coarse refinement areas. To activate the old algorithm used in releases up to v3102.517, specify the batch command:

  ```
  -extrusion-method=3
  ```

during the extrusion generation process.

- The SCHECK command options have been re-named to better represent their purpose. Please view the on-line help or review Appendix C in the pro-am User Manual for a summary of the changes. All the old options are still valid on the command line. The pro-am panel has also been updated accordingly.
- A new surface can now be created from a refined custom mesh without shells being placed on the internal interface of the coarse and fine regions. See Chapter 4 in the pro-am User Manual for additional details.
- The tetrahedral mesher can now triangulate five- and six-sided surface elements automatically prior to creating a tetrahedral cell mesh.
- A tetrahedral quality distribution graph can be plotted automatically from the panel.

Two new tutorials have been added, namely a Surface Wrapping example (Tutorial 4.2) and an Advanced Trimmed Cell example (Tutorial 6) which uses unstructured mesh refinement. The pro-am User Manual also contains many updates to both the text and diagrams. The user is encouraged to review Chapter 4 (Surface Preparation) in particular as it contains additional explanations on the surface checking and modification tools. Other chapters include new sections and/or diagrams to further aid the user while using pro-am.

pro-am v3102.518 also contains the EZAero tool, designed specifically for external aerodynamic analysis. Please contact your sales representative or CD adapco directly if you are interested in this product.

v3103.519 Updates

Release v3103.519 contains a number of bug fixes to the ammbatch program and pro-am panel, as well as some major enhancements. These include:

- Significant speed increases for the cutting code.
- Many improvements to CPmatch generation. A new CPmatch type (3) has been added to indicate CPmatches that have been generated automatically within pro-am.
- Improvements in extrusion layer generation to improve cell quality.
- Improvements in the manner in which the new surface generation option is applied.
- New — Delaunay tet mesher
- New — Supplemented cell division with an advancing front tet mesher to increase reliability, increase speed and reduce the unresolved cell count.
- New — Grow and Tet-fill option around unresolved cells to reduce the unresolved cell count.
- New — Automatic mesh refinement based on surface geometry.
- New — Boolean operations on shell surfaces have been added.
- Improved — Mesh Wizard for building geometry. The wizard now includes more error detection, improved surface usage, automatic template generation based upon surface features, plus the tetrahedral mesher.

pro-am v3103.519 also contains the second release of EZaero, designed specifically for external aerodynamic analysis. It contains the first release of EZuhood, designed for highly complex internal flows typical of vehicle underhoods. It also contains the

first release of EZturbo, designed to produce very refined, elliptically-smoothed meshes around the blades of turbo-machinery equipment. Please contact your sales representative or CD adapco directly if you are interested in any of these products. All EZturbo licenses also include a pro-am license.

v3103.520 Updates

Release v3103.520 contains changes on many fronts. The base pro-STAR code includes a completely rewritten OpenGL-based accelerated graphics mode which is up to four times faster than the previous version. In addition, for users without hardware OpenGL support, the Mesa library is included to provide software emulation of OpenGL. There have also been a number of enhancements and bug fixes to the ammbatch program and the pro-am panels. These include:

- Continued improvement in CPmatch generation.
- New surface has been rewritten and improved.
- Boundary generation for tetrahedral meshes.
- For a certain class of cells, there is much less use of cell division (which results in triangles) to resolve face-based cells.
- A surface improvement procedure has been added. This code improves a triangulated surface in such a way that it can be successfully used to generate a tetrahedral mesh.
- Surface-shell boolean operations.
- A new subsurface method has been added that eliminates the folding and intersection of the subsurface generation. Since there are cases where the subsurface thickness is forced to zero, the extrusion generation code was changed to correctly handle this situation in tetrahedral meshes.

With this release the names of many of the additional tools have changed. What were formally known as “EZtools” (ie EZaero, EZturbo...) have been renamed as “es-tools” (ie es-aero, es-turbo...). “es” stands for “Expert Systems” which more accurately reflects the aim of these tools. There have been a number of bug fixes and improvements in memory handling and error trapping in the es-tools. The major enhancement for v3.103.520 is an overhaul of the Advanced External Aerodynamic Mesh Wizard. Other enhancements include:

- The custom mesh generation now takes advantage of pro-am’s new auto-refine template generation. This adds the ability to refine the mesh based upon curvature, surface proximity, or cell type. The method is quicker and uses memory more efficiently.
- Local refinement can now be specified right on the Mesh Wizard panel. This makes it easier to refine grill openings and local features.
- Prepare Surface/Surface wrapper quality has been improved. The surface wrapper now removes free edges, multi-joins and sharp edges which are generated during the wrapping procedure.
- Generate Subsurface — Simple Extrusion now handles variable subsurface thickness.
- Generate Subsurface — Advanced Subsurface has been added. This is an excellent choice for preventing surface intersections in a tight geometry.
- This mesh wizard originally intended for underhood modeling is now also available with es-aero, to enable it to handle "dirty" CAD data as well.

v3103.521/522 Updates

Beginning with v3103.521, we are moving over to dynamically-linked executables based on shared objects. The shared object executables introduce a new wrinkle on how pro-STAR is executed and how pro-STAR user subroutines are created by requiring a shared library path. For users who start pro-STAR/pro-am/es-Tools using the supplied shell scripts (prostar, proam, esaero, esuhood, etc.), this has already been addressed within the shell script so there is no observable difference. Users who have their own custom scripts, or run the executables directly (such as pro-xm) will need to set shared library paths properly. Machines based on Compaq's Tru64 Unix, Linux, SGI's IRIX or Sun's Solaris will need to set the environment variable shown below:

LD_LIBRARY_PATH = .:$STARDIR/pro:$LD_LIBRARY_PATH

Hewlett Packard HP-UX users will need to set:

SHLIB_PATH = .:$STARDIR/pro:$SHLIB_PATH

IBM AIX users will need to set:

LIBPATH = .:$STARDIR/pro:$LIBPATH

The prolink script will now compile pro-STAR user subroutines into a shared object, `user1.so` (or `user1.sl`, depending on the machine). To properly activate this user-compiled shared object, the file will need to be placed in the current working directory where the user starts pro-STAR. Alternatively, the directory where `user1.so` is located must be prepended to the shared library path. If either one of these is not done, pro-STAR will default to the supplied `user1.so` in the `$STARDIR/pro` directory.

There have been many enhancements to the renderering and meshing capabilities of v3103.521. The rewritten OpenGL-based accelerated graphics mode (extended mode) introduced in v3103.520 has been undergoing further development and optimization:

- Improved — Extended mode now supports plotting of boundaries and splines, rendering features that were previously available only in the standard X11 renderer (non-extended mode).
- Improved — Faster plotting with the caching of view-independent information. This improvement comes at the cost of memory. If memory usage is a problem, the caching may be disabled with RENDEROPT,MEMORY.
- New — High-resolution screen dumps (see online help for HRSDump) that allow arbitrary resolution screen captures of the extended-mode plotting window. This command produces high quality `.png`, `.gif`, or PostScript files. For best results when printing high resolution images with text, set the environment variable STARFONT0 to a scalable font before running pro-STAR.
- Improved — Feature and silhouette edges of complex geometries can now be displayed with hardware acceleration in extended mode.
- New Beta Feature — Plotting layers with the LAYER command. This

CD-adapco

command takes the current plotting primitives (cells, particle tracks, etc.) and stores them in a layer for compositing arbitrary plotting objects. Any number of layers may be overlayed to produce arbitrary combinations of plot types. Unlike the OVERLAY command, the plotting layers are stored as 3D primitives so the view can be changed with the data overlayed.

Release v3103.521 contains a number of bug fixes and some major enhancements to the ammbatch program and pro-am/es-tools panels. These include:

- New — Parallel mesh generation is now possible for all pro-am/es-tools models when using user-defined custom meshes.
- Improved — CPmatch generation has been improved.
- Improved auto-refine process when dealing with arbitrary custom meshes.
- Improved smoothing algorithms to improve triangle and tetra quality.
- Improved — The Delaunay tetrahedral mesher now handles interior baffles. This feature is activated by enabling the “Internal Feature Cell Type” option.
- Improved — The default subsurface method helps prevent self intersections and improves the quality of the cells in the extrusion layer. In addition, subsurfaces can now be put around a baffle.
- Improved memory handling.

Specific enhancements for es-aero and es-uhood include:

- Improved — Added more checks to the geometry write in “Analysis Setup -> Analysis Preparation”. There are now three levels of checking in the geometry write.
- New — Added option “Component Wrap” to the Mesh Wizard’s “Generate Custom Mesh”. This option allows a box to be built around a specified surface which then allows just the selected component to be wrapped.
- New — Added option “Custom (use Domain DBID)” to the Mesh Wizard’s “Generate Custom Mesh”. This will use a pre-generated custom mesh for surface wrapping.
- New — es-aero now supports plotting of drag data from the “Plot ERD data” option.
- Improved — The ground contact patch procedure has been improved.
- New — It is now possible to visually see leakage areas in wrapped surfaces with the “Show Leakage” button.
- New — Steady-state aeroacoustic calculations can be activated in the es-aero panel.
- New — The KE-SST turbulence model can be activated in the es-aero panel.
- New — Added “Resurface” option to es-uhood’s “Prepare Surface -> Surface Tools I” panel. This option improves the triangulation quality of wrapped surfaces.
- New — Added “Fan Template” and “Heat Exchanger Template” panels to “Template Generation” in es-uhood. These will generate a local custom mesh for fans and heat exchangers.

Appendix C CAD Import and Surface Meshing — Version 3.20 Release Notes

The pro-surf tool provides a means to import CAD data, repair common problems and mesh the surfaces in preparation for volume grid generation. It serves as a much improved replacement to the current CAD import facilities available in pro-STAR / pro-am. This release supports reading of CAD data from either IGES or VDA-FS files or, with one of the add-on CAD file readers, directly from CATIA V4, CATIA V5, Unigraphics, STEP and Pro/ENGINEER files. pro-surf includes a suite of automatic CAD repair routines which can fix most CAD problems commonly found in CAD data. Additional manual repair and simple surface/curve creation functions are also available to deal with problems that could not be repaired automatically.

Important Points

- If problems occur with incorrect display of the interface or graphics window, try running the application with the command line option `-cmap`, e.g.
  `/usr/local/star/bin/prosurf-gl -cmap`
  It is recommended that the X-windows display be set to 24-bit depth with the TrueColor visual class. You can check which display is active using the `xdpyinfo` program in X-windows and looking for the number corresponding to the default visual id.
- When trying to read a database file saved from pro-surf into pro-am, set the `Casename` in pro-STAR to be the name of the database file without the `.dbs` extension. When the pro-am window opens, it looks for a file with name `Casename.dbs` in the current working directory. The surface mesh in the database file can also be loaded manually by using the `DBASE` command and options available in pro-STAR.
- Triangular shells must be oriented once the surface mesh has been read into pro-STAR/pro-am. If the CAD model was watertight, i.e. no free curves, the triangulation should also be watertight. The triangulation should also be checked using the surface checks in pro-am (or command `SCHECK`) to make sure that no intersections or non-manifold edges are found. All of the surface checks and orientation will be performed by pro-surf in the future.
- A restart file should always be saved after writing out a database for pro-am. This way, if a problem is found during the surface checks, the user can look at the cell table that contains the problem triangles. The name of the cell table indicates which surface the triangle was on in the CAD model. The pro-surf restart file can be loaded and that surface examined, fixed and/or re-triangulated.
- If you want to triangulate the model or specific surfaces without using the automatic curvature detection, set the minimum size due to curvature to a negative value.
- You can triangulate one or more surfaces while maintaining any previously existing triangles on the other surfaces. However, re-triangulating surfaces with a size much smaller than neighbouring surfaces will result in a very poor quality surface mesh.

- IGES files from Pro/ENGINEER, I-DEAS and SolidWorks usually read in without error and require very little manual cleaning. IGES files exported from CATIA and Unigraphics IGES files work for the most part, but they sometimes exhibit problems with free curves, incomplete trimming loops and incorrectly defined surfaces of revolution.

CAD File Import Notes

The add-on direct CAD file readers allow for importing of CAD model data directly from the files saved by the CAD package. This approach circumvents many of the problems associated with converting the CAD data into IGES and then trying to obtain clean CAD data from it.

Catia V4

Files saved from Catia V4 with the extensions `.dlv`, `.export` and `.model` are all supported by the Catia V4 CAD reader. Currently, only the first model in the file is imported into pro-surf. Catia typically uses a much higher curve tolerance (100 times the point tolerance) than is the default in pro-surf (2.5 times the point tolerance). The point tolerance may need to be increased to get the proper amount of automatic repair. The desired result is to have the lowest point and curve tolerances which still allow for repair of the CAD data.

Catia V5

This reader is a completely separate reader from the Catia V4 reader due to the substantial differences in the two versions. The reader is designed to read Catia V5 files with `.CATPart`, `.CATProduct` and `.cgr` file name extensions.

Unigraphics

Files from Unigraphics Version 15.0 and higher should be supported by the Unigraphics CAD file reader. If an error is encountered during conversion of the solids, you are recommended to enable the *Read solids as faces* option on the *Import Unigraphics File* dialog.

Pro/ENGINEER

Files from Versions 18.0 to 2001 of Pro/ENGINEER are supported by the Pro/ENGINEER CAD file reader. When using the Pro/E file chooser, either the part or assembly file extensions can be filtered for import.

The TTF CAD readers are not currently available for the DEC/Compaq Alpha platform and the position regarding the SGI mips3 platform is still to be confirmed.

The OpenGL HP-UX 11 version of pro-surf now contains TTF CAD readers and the native CAD file readers are also working properly in the Mesa version.

pro-surf executables for the HP-UX Itanium2 platform do not contain CAD readers since there is currently no TTF CAD library for this processor. However, the HP-UX 10.20 and 11.00 versions should run on the Itanium platform.

The STEP file reader is available and users should contact their sales agent if they would like to purchase the optional module for reading STEP files.

TTF CAD Reader Licence Instructions

The CAD readers are licensed separately from pro-surf so additional licences are required before CAD file import can be processed. Unfortunately, the CAD readers are currently only available with node-locked licences. Use one of the following commands to determine the licence ID for the appropriate platform:

Platform	Command to determine system ID
Linux	ifconfig (ethernet hardware address)
IRIX	sysinfo -s
AIX	uname -m
Solaris	hostid
HP-UX	uname -i
Windows	ipconfig /all (ethernet physical address)

The CAD reader licensing has changed in the current version of pro-surf to support the new TTF Group CAD library bundling of modules. If you have CAD reader licences for previous versions of pro-surf, you will need to contact CD adapco Group support to convert your current CAD reader licences to the new format.

Create a file named `ttf_license.dat` and put the licence information sent from the TTF Group in this file. This information should consist of at least three pieces of information, a node-locked bundle licence, a NURBS conversion module, and the appropriate CAD reader module(s). The file should look similar to:

```
# TTF License file
#
# Bundle TTFFundations (Id bddac43e) for TTF-TST
# Valid on machine abcdef01 until Dec-31-2003 (Node-locked)
BND:TTFFundations:5319 2a8b b18d 51c2 aa60 9003 cec0 70e9 13ae 32ba

# List of modules for bundle bddac43e
BNDMDL:CATIAV4-R:9113a1dda3211
BNDMDL:PROENGINEER-R:ea389d6dede24
BNDMDL:Fund-NURBS-Conversion:6d1c067e4bcda
```

The above file contains module licences for reading data from CATIA V4 and Pro/ENGINEER CAD files. pro-surf will look for the `ttf_license.dat` file in the current working directory, then in `$HOME` and finally in `$STARDIR/license/` so you can put the file in any of these three locations.

A message in the command window should be issued indicating the file name where the TTF licence information was found. If a problem is encountered, check the output and verify that the proper licence file was found.

Additional Windows 2000/XP Information

Additional licensing software must be installed to access the TTF CAD readers on Windows machines. This software should be included with the STAR-CD Windows distribution. Run the `RainbowSSD5.39.2.exe` executable to install

the additional licensing software.

Since the TTF CAD reader licence key is based on the hardware address of the Ethernet card, an environment variable called `TTF_LIC_ETHER` must be added to the system and its value set to **1** so that the licences will work properly. Also, the search path for the `ttf_license.dat` file is the current working directory, then `C:\`, and finally `$STARDIR\license\`.

Appendix D STAR-Design — Version 3.20 Release Notes

Introduction

STAR-Design represents one of the new generation of fully integrated CAD and CFD tools being developed by the CD adapco Group. The core of the program is based on a solid model engine integrated with all of the necessary tools to perform CFD analysis. This allows design engineers to create and assemble models of interest, setup any necessary flow conditions, generate a mesh, run and view the results all within one graphical interface. Since the solid modeller tracks the parametric values used during construction, design modifications can be applied quickly and the flow analysis rerun with very little effort.

New Features in this Release

This version of STAR-Design includes many new and changed features in solid modelling, problem definition, and post-processing stages. These changes include:

- **Solid Modelling**
  - Linear and circular patterns.
  - Imprinting of faces and bodies to produce subfaces.
  - Specification of twist and scale during sweep operations.
  - Conversion of a set of water-tight faces into a solid body.
  - Retention of parametric information during fillet and chamfer operations.
  - Specification of points and vectors using local workplane coordinates in addition to global coordinates.
  - Explosion of extruded, revolved, swept, lofted bodies.
- **Problem Definition**
  - Multiple body simulation for Conjugate Heat Transfer, Porous Media, and Rotating Reference Frames.
  - Application of boundary conditions to multiple faces simultaneously.
  - Specification of reference locations and values on domains rather than globally.
- **Post-Processing**
  - Auto-update mode for quick updating of plot items.
  - Visualization of results on multiple domains.
  - Cell and Boundary Types dialog to control visibility and colour of individual cell and boundary types.
  - Palette controls for contour plots.
  - Point and line probes of scalar and vector data.
  - Advanced selection modes for point indication.

Transitioning from Version 3.15

To support new multi-body physics such as conjugate heat transfer, porous media, and rotating reference frames, some fundamental methods of applying material properties and boundary conditions had to change. Even for cases with only a single body and a single domain, some operations must be done differently from STAR-Design 3.15. The two biggest changes for users experienced with STAR-Design 3.15 are:

1. Materials are no longer associated with individual bodies. Instead, bodies are assigned to domains to which material properties are then assigned. For single-body, single-domain cases, this simply means that the material should be assigned by selecting the Fluid domain in the Domain Tree and modifying the Material property.

2. Boundary conditions are no longer associated with individual faces. Instead, faces are assigned to boundaries to which actual boundary conditions are then assigned. In addition to supporting the new multi-body physics in this release, this also allows multiple faces to be grouped together into a single boundary so changes to the boundary's properties affect all assigned faces. New boundaries are created by selecting the *BOUNDARIES* placeholder in the **Domain Tree** and pressing the **Add** button. These boundaries can then be assigned to faces by selecting the faces in the graphics window and pressing the **Assign** button.

For a more detailed description of these features, please consult the STAR-Design Users Guide or Tutorials.

Important Notes

1. Here is the list of the currently supported operating system names and versions:

   HP-UX 11.0 — 64 bit and 64 bit Itanium
   AIX 4.3 — 32 bit
   Linux 2.2 — 32 bit
   IRIX64 6.4 — 32 bit
   SunOS 5.8 — 64 bit
   Windows 2000, XP — 32bit

2. Appropriate 32 bit versions of STAR-Design are also installed with 64 bit installations of STAR-CD of AIX, Linux, and IRIX. For users running the Linux operating systems on platforms with the Itanium chipset, the 32 bit STAR-Design will run but performance may not be optimal. In these cases, the installed 64 bit version of the mesh generators and solvers will be used, so overall performance should be reasonable.

3. A "stardesign" licence feature **and** a "starsuite" licence is required in order to run STAR-Design. A ''-nosolve'' command line option is available which uses ''stardesign'' **and** ''prostar'' licence features, however, only pre- and post-processing are allowed in this mode, the solver cannot be run.

4. To run STAR-Design on a Unix platform, execute the stardesign script located in the $STARDIR/bin directory. If $STARDIR/bin was added to the current search path, then just enter "stardesign" at the command prompt. For Windows, a stardesign batch script (stardesign.bat) is located in the $STARDIR/bin directory. Alternatively, it is possible to execute STAR-Design from the STAR-Launch GUI.

5. When a session is saved while running STAR-Design, all of the grid and run

information will be saved into a subdirectory with the given session name. This subdirectory will contain the pro-cad solid model file (.pcd), the pro-surf restart file (.ezs), the ammbatch database file(.dbs), and the grid files (.dbs and .ngeom). Also, if the solver has been run, all of the solver files will be saved into a subdirectory named “star”.

6. If a problem occurs during the middle of a STAR-Design session, all of the temporary files (pro-cad, pro-surf, pro-am database, and ngeom) will be stored in a scratch directory called “tmp_stardesign” located in the directory where STAR-Design was run. This directory also contains the output log from ammbatch for the volume mesh generation.

7. If you have problems running the OpenGL version, you can use the included Mesa shared GL libraries on some platforms by selecting the mesa option when running the “stardesign” script.

8. On newer Linux kernels, if you receive an error complaining about GLIBC_2.0 not defined in libc.so.6, then uncomment the two lines in the STAR-Design script referring to LD_ASSUME_KERNEL.

If you encounter a repeatable problem, please contact us (email: support@us.cd-adapco.com). Also, any suggestions for improvement of this software in terms of functionality and ease of use would be welcome.

Frequently Asked Questions

1. *How do I change the view while in object selection or creation mode?*
   Hold down the ‘‘Ctrl’’ key on the keyboard to override the current mouse mode and switch to view control.

2. *I just pressed one of the scroll buttons in the view box and my model won’t stop spinning!*
   This problem has been reported but is not easily reproducible and has not yet been fixed. If this happens, simply minimize your STAR-Design window and restore it.

3. *How do I select a face that has been made invisible?*
   Using the right mouse button while in face select mode cycles through all faces under the mouse, starting with the visible ones. Just right click on the location where the face should be until the desired face has been selected.

4. *How do I assign grid sizing to specific faces?*
   Enable Select mode and make sure the Select Face button is toggled down. Left click on the face and then click on the Properties tab (with the Solid Model Tab selected) in the lower right corner panel. The properties including grid size can then be modified. Make sure to press the Update button to accept the changes.

5. *How do I stop the grid generation or solver when they are running?*
   Press the Abort button at the very bottom right of the interface. This will stop the grid generation process instantly while the solver will wait until the

current iteration, write out a restart file, and then stop.

6. *Why does the Undo button not always work properly?*
   The Undo/Redo operation only applies to the solid modelling portion of STAR-Design. A grid generation or solver process cannot be undone.

7. *Why can't I generate a mesh for my multi-body model?*
   In order to generate a proper mesh, certain rules about the interfaces between multiple bodies must be followed. Specifically, these are:

   - All bodies must be topologically connected across identical faces to form a single region of space.
   - Two fluid domains cannot be in contact with one another.
   - Each domain must be contiguous, i.e. cannot consist of two bodies that are not in contact.

   For more details on these rules, please see the STAR-Design user guide.